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JAMES WILSON

JAMES WILSON

A
TREATISE
ON
SURVEYING,
CONTAINING
THE THEORY AND PRACTICE:
TO WHICH IS PREFIXED
A PERSPICUOUS SYSTEM
OF
PLANE TRIGONOMETRY.

THE WHOLE CLEARLY DEMONSTRATED AND ILLUSTRATED BY A LARGE NUMBER
OF APPROPRIATE EXAMPLES,

PARTICULARLY ADAPTED TO THE USE OF SCHOOLS.

BY JOHN GUMMERE, A. M.
FELLOW OF THE AMERICAN PHILOSOPHICAL SOCIETY, AND CORRESPONDING MEMBER
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FOURTEENTH EDITION,
CAREFULLY REVISED, AND ENLARGED BY THE ADDITION OF
ARTICLES ON THE
THEODOLITE, LEVELLING, AND TOPOGRAPHY

PHILADELPHIA:
PUBLISHED BY KIMBER & SHARPLESS,
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PREFACE.

The following compilation originated in the belief that our schools are in want of a Treatise on Surveying, adapted to the methods practised in this country, and freed from the defects of the systems now in use. Notwithstanding the importance of the science, and the large number that make it an object of study, it is believed we are not in possession of a treatise on this subject, suited to the wants of the student. The works of Gibson and Jess are the only ones at present in general use; the former, though much the better of the two, is deficient in many respects. It may be sufficient here, merely to advert to its want of examples, which renders it entirely unsuitable for a school book. From the latter, the student would in vain expect to become acquainted with the principles of the science, or the *rationale* of any of the rules, necessary in performing the various calculations.*

In order to understand the principles of surveying, a previous knowledge of Geometry is absolutely necessary; and this knowledge will be best acquired from a regular treatise on the subject. In the demonstrations, therefore, throughout this work, the student is supposed to be acquainted with the elements of that science. The references are adapted to Playfair's Geometry, but they will in general apply equally well to Simson's translation of Euclid's Elements.

As there are many who wish to obtain a practical knowledge of Surveying, whose leisure may be too limited to admit of their going through a course of Geometry, the author has adapted his work to this class, by introducing the necessary geometrical definitions and problems, and by giving plain and concise rules, entirely detached from the demonstrations; the latter being placed in the form of notes at the bottom of the page. Each rule is exemplified by one wrought example; and the most of them by several unwrought examples, with the answers annexed.

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* Each of these works has lately gone through a new edition, in which considerable additions are stated to have been made. On examination, however, it does not appear, that those additions are such as to supply the deficiencies.

The additions made to Gibson, consist principally of some nautical problems quite foreign to a treatise on Surveying. Those made to Jess, consist of a few extracts from Gibson, in one of which the Pennsylvania method of calculation is introduced, as being quite different from that given by Jess; whereas it is well known to be the method given by that author, and used, as well in the preceding, as in the subsequent part of his work.

1*

In the laying out and dividing of land, which forms the most difficult part of surveying, a variety of problems is introduced, adapted to the cases most likely to occur in practice. This part of the subject, however, presents such a great variety of cases, that we should in vain attempt to give rules that would apply to all of them. It cannot therefore be too strongly recommended to every one, who has the opportunity, to make himself well acquainted with Geometry, and also with Algebra, previous to entering on the study of Surveying. Furnished with these useful auxiliaries, and acquainted with the principles of the science, the practitioner will be able to perform, with ease, any thing likely to occur in his practice.

The compiler thinks proper to acknowledge, that in the arrangement of the work, he availed himself of the advice of his learned preceptor and friend, E. Lewis of New-Garden; and that several of the demonstrations were furnished by him.

ADVERTISEMENT TO THE FOURTH EDITION.

In preparing this edition for the press, several alterations have been made, which, it is believed, will be found to be real improvements. A number of new Problems has been introduced, and a more methodical arrangement of the whole has been adopted. Instead of three different rules for calculating the content of a Survey, one *general* rule, including these, is now given. It may be further added, that the rules for solving several of the problems in Division of Land, have been considerably simplified. The Mathematical Tables have been stereotyped, after carefully revising them and comparing them with the most correct European Editions.

THE AUTHOR.

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To meet the wants of the Student of Civil Engineering, this edition has been enlarged by the addition of several chapters, in which the Theodolite and Levelling Instrument are described, the methods of adjusting and using them are given, and the principles and practice of Levelling and Topography are explained and illustrated.—The whole has been carefully revised and the few typographical errors existing in former editions have been corrected.

J. G.

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EXPLANATION

OF THE

CHARACTERS USED IN THIS WORK.

+	signifies *plus*, or addition.
−	*minus*, or subtraction.
×	multiplication.
÷	division.
: :: :	proportion.
=	equality.
√	square root.
∽	difference between two quantities when it is not known which is the greater.

A

TREATISE ON SURVEYING.

OF LOGARITHMS

Logarithms are a series of numbers so contrived, that by them the work of multiplication is performed by addition, and that of division by subtraction.

If a series of numbers in arithmetical progression be placed as indices, or exponants, to a series of numbers in geometrical progression, the sum or difference of any two of the former, will answer to the product or quotient of the two corresponding terms of the latter. Thus,

0. 1. 2. 3. 4. 5. 6. 7. &c. arith. series, or indices.
1. 2. 4. 8. 16. 32. 64. 128. &c. geom. series.

Now $2+3=5$. also $7-3=4$.
And $4\times 8=32$. and $128\div 8=16$.

Therefore the arithmetical series, or indices, have the same properties as logarithms; and these properties hold true, whatever may be the ratio of the geometrical series.

There may, therefore, be as many different systems of logarithms, as there can be taken different geometrical series, having unity for the first term. But the most convenient system is that in which the ratio of the geometrical series is 10; and this is the one in common use. Thus,

0. 1. 2. 3. 4. 5. &c. indices or logar.
1. 10. 100. 1000. 10000. 100000. &c. natural numbers

In this system the log. of 1. is 0,[*] the log. of 10 is 1. the log. of 100, is 2, &c. Hence it is plain that the log. of any number between 1 and 10, will be expressed by a decimal, the log. of any number between 10, and 100, by 1 and a decimal, the log. of any number between 100 and 1000, by 2 and a decimal, &c.

The numbers, 0, 1, 2, 3, &c. that stand before the decimal part of logarithms, are called *indices* and are always less by unity, than the number of figures in the integral part of the corresponding natural number.

The index of the logarithm of a number, consisting in whole, or in part of integers, is affirmative; but if the number be a decimal, the index is negative, and is marked by a negative sign (—) placed either before or above it. If the first significant figure of the decimal be adjacent to the decimal point, the index is, —1, or $\bar{1}$; if there be one cipher between them, the index is —2, or $\bar{2}$; if there be two ciphers between them, the index is —3 or $\bar{3}$, &c.

The decimal parts of the logarithms of numbers, consisting of the same figures and in the same order, are the same, whether the number be integral, fractional, or mixed. This is illustrated as follows:

---

[*] In every system the logarithm of 1 is 0.

Number 18960	Logarithm 4.27784
1896	3.27784
189.6	2.27784
18.96	1.27784
1.896	0.27784
.1896	—1.27784
.01896	—2.27784
.001896	—3.27784
.0001896	—4.27784

The method of finding logarithms in the tables, and of multiplying, dividing, &c. by them, is contained in the following problems.

PROBLEM I.

To find the Logarithm of a given number.

If the given number consists of *one* or *two* figures only, find it in the column marked *No.* in the first page of the table, and against it, in the next column, marked *log.* is the logarithm. Thus the log. of 7 will be found 0.84510, and the log. of 85 will be found 1.92942.

But if the given number be either wholly or in part decimal, the index must be changed accordingly. Observing that the index must always be one less than the number of figures in the integral part of the given number; also, when the given number is wholly a decimal, the index is negative, and must be one more than the number of the ciphers between the decimal point and first significant figure on the left hand. Thus the log. of .7 is —1.84510, and the log. of .0085 is —3.92942.

If the given number consists of *three* figures, find it in one of the other pages of the table, in the column marked *No.* and against it, in the next column, is the decimal part of the logarithm. The index must be placed before it agreeably to the above observation. Thus the log. of 421 is 2.62428, the log. of 4.21 is 0.62428, and the log. of .0421 is —2.62428.

If the given number consists of *four* figures, find the three left hand figures in the column marked *No.* as before, and the remaining, or right hand figure at the top of the table; in the column under this figure, and against the other three, is the decimal part of the logarithm. Thus the log. of 5163 is 3.71290, and the log. of .6387 is —1.80530.

If the given number consist of *five* or *six* figures, find the logarithm of the four left hand figures as before; then take the difference between this logarithm and the next greater in the table. Multiply this difference by the remaining figure or figures of the given number, and cut off one, or two figures to the right hand of the product, according as the multiplier consists of one, or two figures; then add the remaining figure or figures of the product to the logarithm first taken out of the table, and the sum will be the logarithm required. Thus, let it be required to find the logarithm of 59686; then,

Logarithm of 5968 is - -	77583
The next greater log. is - -	77590
Difference - - - -	7
Remaining figure - - -	6
Product - - - - -	4,2
To - - - - -	77583
Add - - - - -	4
Decimal part of the log. - -	77587

The natural number consisting of five integers, the index must be 4; therefore the log. of 59686 is 4.77587.

Again, let it be required to find the log. of .0131755; then,

Logarithm of 1317 is	11959
The next greater log. is	11991
Difference	32
Remaining figures	55
Product	17,60
To	11959
Add	18*
Decimal part of the log.	11977

As the given number is a decimal, and has one cipher between the decimal point and first significant figure, the index must be —2; therefore the log. of .0131755 is —2.11977.

Examples.

1. Required the log. of 4.3 *Ans.* 0.63347
2. Required the log. of 7986 *Ans.* 3.90233
3. Required the log. of .3754 *Ans.* –1.57449
4. Required the log. of 596.87 *Ans.* 2.77588
5. Required the log. of 785925 *Ans.* 5.89538
6. Required the log. of 6543900 *Ans.* 6.81583
7. Required the log. of .0027863 *Ans.* –3.44503

---

* Because 17.6 is nearer 18 than 17.

PROBLEM II.

To find the natural number corresponding to a given logarithm.

If *four* figures only be required in the answer, look in the table for the decimal part of the given logarithm, and if it cannot be found exactly, take the one nearest to it, whether greater or less; then the three figures in the first column, marked *No.* which are in a line with the logarithm found, together with the figure at the top of the table directly above it, will form the number required. Observing, that when the index of the given logarithm is affirmative, the integers in the number found, must be one more than the number expressed by the index; but when the index of the given logarithm is negative, the number found will be wholly a decimal, and must have one cypher less, placed between the decimal point and first significant figure on the left hand, than the number expressed by the index. Thus the natural number corresponding to the logarithm 2.90233 is 798.6, the natural number corresponding to the logarithm 3.77055 is 5896, and the natural number corresponding to the logarithm —3.36361 is .00231.

If the exact logarithm be found in the table, and the figures in the number corresponding do not exceed the index by one, annex ciphers to the right hand till they do. Thus the natural number corresponding to the logarithm 6.64068 is 4372000.

If *five* or *six* figures be required in the answer, find, in the table, the logarithm next less than the given one, and take out the four figures answering to it as before. Subtract this logarithm from the next greater in the table, and also from the given logarithm; to the latter difference, annex one or two ciphers, according as five or six figures are required, and divide the number thus produced, by the former difference; annex the quotient to the right hand of the four figures already found, and it will give the natural number required.

Thus let it be required to find the natural number corresponding to the logarithm 2.53899 true to *five* figures; then,

Given logarithm - .53899
Next less - - - - .53895 the natural number
——— corresponding is 3459
Diff. with one cipher annexed 40

Next less log. - - .53895
Next greater - - .53908
———
Difference 13

Divide 40 by 13 and the quotient will be 3, which, annexed to the right hand of 3459, the four figures already found, makes 34593; therefore as the index is 2, the required natural number is 345.93.

Again let it be required to find the natural number corresponding to the logarithm 4.59859, true to *six* figures; then,

Given logarithm - - .59859
Next less - - - - - .59857, the natural number an-
——— swering to it is 3968.
Diff. with two ciphers annexed 200

Next less log. - - - 59857
Next greater - - - 59868
———
Difference - - - - 11

Divide 200 by 11, and the quotient will be 18, which annexed to the right hand of 3968, the four figures already found, makes 396818; therefore as the index is 4, the required natural number is 39681.8.

EXAMPLES.

1. Required the natural number answering to the logarithm 1.88030. *Ans.* 75.91.

2. Required the natural number answering to the logarithm 5.37081. *Ans.* 234861.

3. Required the natural number answering to the logarithm 3.11977. *Ans.* 1317.56.

4. Required the natural number answering to the logarithm—2.97435. *Ans.* .094265.

PROBLEM III.

To multiply numbers by means of logarithms.

Case 1.—When all the factors are whole or mixed numbers.

RULE.

Add together the logarithms of the factors, and the sum will be the logarithm of the product.

EXAMPLES.

1. Required the product of 84 by 56.

Logarithm of 84	is	1.92428
Do. of 56	is	1.74819
Product 4704	Sum	3.67247

2. Required the continued product of 17.3, 1.907 and 34.

Logarithm of 17.3	is	1.23805
Do. 1.907	is	0.28035
Do. 34.	is	1.53148
Product 1121.71	Sum	3.04988

3. Find by logarithms the product of 76.5 by 5.5 *Ans.* 420.75.

4. Find by logarithms the continued product of 42.35, 1.7364, and 1.76. *Ans.* 129.424.

Case 2.—When some or all of the factors are decimal numbers.

RULE.

Add the decimal parts of the logarithms as before, and if there be any to carry from the decimal part, add it to the affirmative index or indices, or else subtract it from the negative.

Then add the indices together, when they are all of the same kind; that is, all affirmative or all negative; but when they are of different kinds, take the difference between the sums of the affirmative and negative ones, and prefix the sign of the greater.

Note.—When the index is affirmative, it is not necessary to place any sign before it; but when it is negative, the sign must not be omitted.

EXAMPLES.

1. Required the continued product of 349.17, 25.43, .93521 and .00576.

Logarithm of	349.17	is	2.54303
Do.	25.43	is	1.40535
Do.	.93521	is	–1.97090
Do.	.00576	is	–3.76042
Product 47.83		Sum	1.67970

In this example there is 2 to carry from the decimal part of the logarithms, which added to 3, the sum of the affirmative indices, makes 5; from this taking 4, the sum of the negative indices, the remainder is 1, which is the index of the sum of the logarithms, and is affirmative, because the sum of the affirmative indices, together with the number carried, exceeds the sum of the negative indices

2. Required the continued product of .0839, .7536, and .003179.

Logarithm of	.0839	is	–2.92376
Do.	.7536	is	–1.87714
Do.	.003179	is	–3.50229
Product .000201		Sum	–4.30319

In this example there is 2 to carry from the decimal part of the logarithms, which subtracted from 6, the sum of the negative indices, leaves 4, which is the index of the sum of the logarithms, and is negative, because the sum of the negative indices is the greater.

3. Required the continued product of 13.19, .3765, and .00415. *Ans.* .02061.

4. Required the continued product of 343, 1.794, 5.41, and .019. *Ans.* 63.25.

PROBLEM IV.

To divide numbers by means of Logarithms.

Case 1.—When the dividend and divisor are both whole or mixed numbers.

RULE.

From the logarithm of the dividend, subtract the logarithm of the divisor, the remainder will be the logarithm of the quotient.

Note.—When the divisor exceeds the dividend, the question must be wrought by the rule given in the next case.

EXAMPLES.

1. Required the quotient of 3450 divided by 23.

Logarithm of	3450	is	3.53782
Do.	23	is	1.36173
Quotient 150	Remainder		2.17609

2. Required the quotient of 420.75 divided by 76.5. *Ans.* 5.5.

3. Required the quotient of 37.1542 divided by 1.73958. *Ans.* 21.3585.

CASE 2.—When the dividend or divisor, or both of them, are decimal numbers.

RULE.

Subtract the decimal parts of the logarithms as before, and if 1 be borrowed in the left hand place of the decimal part, add it to the index of the divisor when that index is affirmative, but subtract it when negative.

Then conceive the sign of the index of the divisor changed from affirmative to negative, or from negative to affirmative; and if, when changed, it be of the same name with that of the dividend, add the indices together but if it be of a different name, take the difference of the indices, and prefix the sign of the greater.

EXAMPLES.

1. Required the quotient of .7591 divided by 32.147

Logarithm of .7591 is -1.88030
Do. 32.147 is 1.50714

Quotient .02361 Remain. -2.37316

In this example, the index of the divisor, with its sign changed, is —1, which added to —1, the index of the dividend, makes —2, for the index of the quotient.

2. Required the quotient of .63153 divided by .00917.

Logarithm of .63153 is -1.80039
Do. .00917 is -3.96237

Quotient 68.8683 Remain. 1.83802.

In this example there is 1 to carry from the decimal part of the logarithm, which subtracted from —3, the index of the divisor, leaves —2; this, with its sign changed, is +2; from which subtracting 1, the index of the dividend, the remainder is 1, and is affirmative, because the affirmative index is the greater.

3. Required the quotient of 13.921 divided by 7965.13

Logarithm of 13.921 is 1.14367
Do. 7965.13 is 3.90125

Quotient .001748 Remain. -3.24242

In this example there is 1 to carry from the decimal part of the logarithm, which added to 3, the index of the divisor, makes 4; this, with its sign changed, is, —4; from which subtracting 1, the index of the dividend, the remainder is —3.

4. Required the quotient of 79.35 divided by .05178.
Ans. 1532.46.

5. Required the quotient of .5903 divided by .931.
Ans. .63404.

PROBLEM V.

To involve a number to any power, that is, to find the square, cube, &c. of a number, logarithmically.

RULE.

Multiply the logarithm of the given number by the index of the power, viz. by 2 for the square, by 3 for the cube, &c. and the product will be the logarithm of the power.

Note.—When the index of the logarithm is negative, if there be any to carry from the decimal part, instead of adding it to the product of the index and multiplier, subtract it, and the remainder will be the index of the logarithm of the power, and will always be negative.

EXAMPLES.

1. Required the square of 317.

Logarithm of 317	is	2.50106
		2
Square 100489		5.00212

2. Required the 5th power of 1.735.

Logarithm of 1.735	is	0.23930
		5
5th power 15.7218		1.19650

3. Required the cube of .08761.

Logarithm of .08761	is	–2.94255
		3
Cube .0006724		–4.82765

4. Required the cube of 7.503. *Ans.* 422.37.

5. Required the 7th power of .32513. *Ans.* .0003841

PROBLEM VI.

To extract any root of a number logarithmically.

RULE.

Divide the logarithm of the given number by the index of the root, that is, by 2 for the square root, by 3 for the cube root, &c. and the quotient will be the logarithm of the required root.

Note.—When the index of the logarithm is negative, and does not exactly contain the divisor, increase the index by a number just sufficient to make it exactly divisible by it, and carry the units borrowed, as so many tens, to the left hand figure of the decimal part; then proceed with the division in the usual manner.

EXAMPLES.

1. Required the cube root of 391.27.

3)
Logarithm of 391.27 is 2.59248

Cube root 7.314 0.86416

2. Required the square root of .08593.

2)
Logarithm of .08593 is —2.93414

Square root .29314 —1 46707

3. Required the cube root of .7596.

3)
Logarithm of .7596 is —1.88058

Cube root .9124 —1.96019

4. Required the cube root of .0000613.

3)
Logarithm of .0000613 is —5.78746

Cube root .03943 —2.59582

5. Required the square root of 365. *Ans.* 19.105.
6. Required the 5th root of .9563. *Ans.* .9911.
7. Required the 4th root of .00079. *Ans.* .16765

Of the Arithmetical Complements of Logarithms.

When it is required to subtract several logarithms from others, it will be more convenient to convert the subtraction into an addition, by writing down, instead of the logarithms to be subtracted, what each of them wants of 10.00000, which may readily be done, by writing down what the first figure, on the right hand, wants of 10, and what every other figure wants of 9; this remainder is called the *Arithmetical Complement.* Thus, if the logarithm be 2.53061, its arithmetical complement will be 7.46939. If one or more figures to the right hand be ciphers, write ciphers in their place, and take the first significant figure from 10, and the remaining figures from 9. Thus, if the logarithm be 4.61300, its arithmetical complement will be 5.38700.

In any operation, where the arithmetical complements of logarithms are added to other logarithms, there must be as many tens subtracted from the sum, as there are arithmetical complements used.

As an example, let it be required to divide the product of 76.4 and 35.84, by the product of 473.9 and 4.76.

473.9	- -	Ar. Co. 7.32431
4.76	- -	Ar. Co. 9.32239
35.84	- -	log. 1.55437
76.4	- -	log. 1.88309
Quotient 1.214		0.08416

GEOMETRY.

DEFINITIONS.

1. GEOMETRY is that science wherein the properties of magnitude are considered.

2. A *point* is that which has position, but not magnitude.

3. A *line* has length but not breadth.

4. A *straight*, or *right line*, is the shortest line that can be drawn between any two points.

5. A *superficies* or *surface* is that which has length and breadth, but not thickness.

6. A *plane superficies* is that in which any two points being taken, the straight line which joins them lies wholly in that superficies.

7. A *plane rectilineal angle* is the inclination of two straight lines to one another, which meet together, but are not in the same straight line, as A, Fig. 1.

Note.—When several angles are formed about the same point, as at B, Fig. 2, each particular angle is expressed by three letters, whereof the middle letter shows the angular point, and the other two the lines that form the angle; thus, CBD or DBC signifies the angle formed by the lines CB and DB.

8. The *magnitude* of an *angle* depends on the inclination which the lines that form it have to each other, and not on the length of those lines. Thus the angle DBE is greater than the angle ABC, Fig. 3.

9. When a straight line stands on another straight line so as to incline to neither side, but makes the angles on each side equal, then each of those angles is called a *right angle*, and the line which stands on the other is said to be *perpendicular* to it. Thus ADC and BDC are right angles, and the line CD is perpendicular to AB, Fig. 4.

10. An *acute* angle is that which is less than a right angle, as BDE, Fig. 4.

11. An *obtuse* angle is that which is greater than a right angle, as ADE, Fig. 4.

12. *Parallel straight lines* are those which are in the same plane, and which, being produced ever so far both ways, do not meet, as AB, CD, Fig. 5.

13. A *figure* is a space bounded by one or more lines.

14. A *plane triangle* is a figure bounded by three straight lines, as ABC, Fig. 6.

15. An *equilateral* triangle has its three sides equal to each other, as A, Fig. 7.

16. An *isosceles* triangle has only two of its sides equal, as B, Fig. 8.

17. A *scalene* triangle has three unequal sides, as ABC, Fig. 6.

18. A *right angled* triangle has one right angle, as ABC, Fig. 9; in which the side AC, opposite to the right angle, is called the *hypothenuse*.

19. An *obtuse angled triangle* has one obtuse angle, as C, Fig. 10.

20. An *acute angled triangle* has all its angles acute, as ABC, Fig. 6.

21. Acute and obtuse angled triangles are called *oblique angled triangles.*

22. Any plane figure bounded by four right lines, is called a *quadrilateral.*

23. Any quadrilateral, whose opposite sides are parallel, is called a *parallelogram,* as D, Fig. 11.

24. A parallelogram, whose angles are all right angles, is called a *rectangle,* as E, Fig. 12.

25. A parallelogram whose sides are all equal, and angles right, is called a *square,* as F, Fig. 13.

26. A *rhomboides* is a parallelogram, whose opposite sides are equal, and angles oblique, as D, Fig. 11.

27. A *rhombus* is a parallelogram, whose sides are all equal and angles oblique, as G, Fig. 14.

28. Any quadrilateral figure that is not a parallelogram, is called a *trapezium.*

29. A trapezium that has two parallel sides is called a *trapeziod.*

30. A right line joining any two opposite angles of a quadrilateral figure, is called a *diagonal.*

31. That side upon which any parallelogram, or triangle is supposed to stand, is called the *base ;* and the perpendicular falling thereon from the opposite angle is

called the *altitude* of the parallelogram, or triangle. Thus AD is the base of the parallelogram ABEC, or triangle ABC, and CD is the altitude. Fig. 15.

32. All plane figures contained under more than four sides, are called *polygons;* of which those having five sides, are called *pentagons;* those having six sides, *hexagons*, and so on.

33. A *regular polygon* is one whose angles, as well as sides, are all equal.

34. A *circle* is a plane figure, bounded by one curve line called the *circumference* or *periphery*, every part of which is equally distant from a certain point within the circle; and this point is called the *centre*, Fig. 16.

35. The *radius* of a circle is a straight line drawn from the centre to the circumference, as CB, Fig. 17.

36. The *diameter* of a circle is a straight line drawn through the centre, and terminated both ways by the circumference, as AE, Fig. 17. It divides the circle into two equal parts, called *semicircles.*

37. A *quadrant* is one quarter of a circle, as ACB, Fig. 17.

Note.—The fourth part of the circumference of a circle is also called a quadrant.

38. A *segment* of a circle is the figure contained by a right line, and the part of the circumference it cuts off: thus AEBA and AEDA are segments of the circle ABED, Fig. 16.

39. An *arc* of a circle is any part of the circumference; as AD or DE, Fig. 17.

40. *Ratio* is a mutual relation between two quantities of the same kind with respect to magnitude

Note.—A ratio is generally expressed, either by two numbers or by two right lines.

41. When two quantities have the same ratio as two other quantities, the four quantities taken in order are called *proportionals ;* and the last is said to be a *fourth proportional* to the other three.

42. When three quantities of the same kind are such that the first has to the second the same ratio which the second has to the third, the third is called a *third proportional* to the first and second, and the second is called a *mean proportional* between the first and third.

GEOMETRICAL PROBLEMS.

PROBLEM I.

To bisect a right line, AB, Fig. 18.

Open the dividers to any distance more than half the line AB, and with one foot in A, describe the arc CFD; with the same opening, and one foot in B, describe the arc CGD, meeting the first arc in C and D; from C to D draw the right line CD, cutting AB in E, which will be equally distant from A and B.

PROBLEM II.

At a given point A, *in a right line* EF, *to erect a perpendicular,* Fig. 19.

From the point A, lay off on each side, the equal distances AC, AD; from C and D, as centres, with any radius greater than AC or AD, describe two arcs intersecting each other in B; from A to B, draw the line AB, which will be the perpendicular required.

PROBLEM III.

To raise a perpendicular on the end B *of a right line* AB, Fig. 20.

Take any point D not in the line AB, and with the distance from D to B, describe a circle cutting AB in E; from E through D draw the right line EDC, cutting the periphery in C, and join CB, which will be perpendicular to AB.

PROBLEM IV.

To let fall a perpendicular upon a given line BC, *from a given point* A, *without it*, Fig. 21.

In the line BC take any point D, and with it as a centre and distant DA describe an arc AGE, cutting BC in G; with G as centre, and distance GA, describe an arc cutting AGE in E, and from A to E draw the line AFE; then AF will be perpendicular to AB.

PROBLEM V.

Through a given point A *to draw a right line* AB, *parallel to a given right line* CD, Fig. 22.

From the point A to any point F, in the line CD, draw the right line AF; with F as a centre and distance FA, describe the arc AE, and with the same distance and centre A describe the arc FG; make FB equal to AE, and through A and B draw the line AB, and it will be parallel to CD.

PROBLEM VI.

At a given point B, *in a given right line* LG, *to make an angle equal to a given angle* A, Fig. 23.

With the centre A and any distance AE, describe the arc DE, and with the same distance and centre B describe the arc FG; make HG equal to DE, and through B and H draw the line BH; then will the angle HBG be equal to the angle A.

PROBLEM VII.

To bisect any right lined angle BAC, Fig. 24.

In the lines AB and AC, from the point A, set off equal distances, AD and AE; with the centres D and E and any distance more than half DE, describe two arcs cutting each other in F; from A through F draw the line AG, and it will bisect the angle BAC.

PROBLEM VIII.

To describe a triangle that shall have its sides respectively equal to three right lines, D, E, *and* F, *of which any two must be together greater than the third*, Fig. 25.

Make AB equal to D; with the centre A and distance equal to E, describe an arc, and with the centre B and distance equal to F describe another arc, cutting the former in C; draw AC and BC, and ABC is the triangle required.

PROBLEM IX.

Upon a given line AB *to describe a square*, Fig. 26.

At the end B of the line AB, by Problem III. erect the perpendicular BC, and make it equal to AB; with A and C as centres, and distance AB or BC describe two arcs cutting each other in D; draw AD, and CD, then will ABCD be the square required.

PROBLEM X.

To describe a circle that shall pass through the angular points, A, B, *and* C, *of a triangle* ABC, Fig. 27.

By Problem I. bisect any two of the sides, as AC, BC, by the perpendiculars DE and FG; the point H where they intersect each other will be the centre of the circle: with this centre, and the distance from it to either of the points A, B, or C, describe the circle.

PROBLEM XI.

To divide a given right line AB *into any number of equal parts,* Fig. 28.

Draw the indefinite right line AP, making an angle with AB, also draw BQ, parallel to AP, in each of which, take as many equal parts AM, MN, &c. *Bo*, *on*, &c. as the line AB is to be divided into; then draw *Mm*, *Nn*, &c. intersecting AB in E, F, &c. which will divide the line as required.

PROBLEM XII.

To make a plane diagonal scale, Fig. 29.

Draw eleven lines parallel to, and equidistant from each other; cut them at right angles by the equidistant lines BC; EF; 1, 9; 2, 7; &c. then will BC, &c. be divided into ten equal parts; divide the lines EB, and FC, each into ten equal parts; and from the points of division on the line EB, draw diagonals to the points of division on the line FC: thus join E and the first division on FC, the first division on EB, and the second on FC, &c.

Note.—Diagonal scales serve to take off dimensions or numbers of three figures. If the first large divisions be units, the second set of divisions, along EB, will be

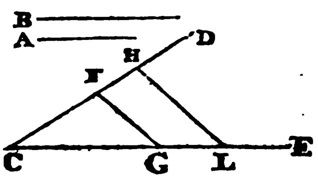
10th parts; and the divisions in the altitude, along BC, will be 100th parts. If HE be tens, EB, will be units, and BC will be tenth parts. If HE be hundreds, BE will be tens, and BC units. And so on, each set of divisions being tenth parts of the former ones.

For example, suppose it were required to take off 242 from the scale. Extend the dividers from E to 2 towards H; and with one leg fixed in the point 2, extend the other till it reaches 4 in the line EB; move one leg of the dividers along the line 2, 7, and the other along the line 4, till they come to the line marked 2, in the line BC, and that will give the extent required.

PROBLEM XIII.

To find a third proportional to two given right lines, A *and* B.

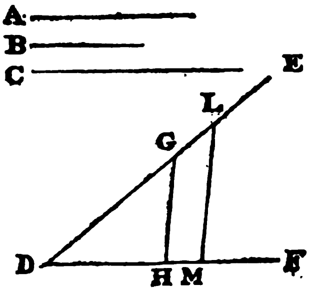
Draw two right lines, CD, CE containing any angle; make CF equal A, and CG, CH, each equal B; join FG and draw HL parallel to it: then will CL be the third proportional required.



PROBLEM XIV.

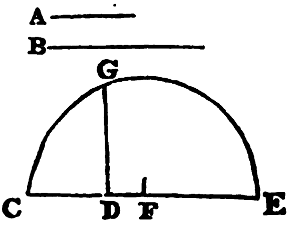
To find a fourth proportional to three given right lines, A, B *and* C.

Draw two right lines, DE, DF containing any angle; make DG equal A, DH equal B, and DL equal C; join GH and draw LM parallel to it: DM will be a fourth proportional to A, B, and C.



PROBLEM XV.

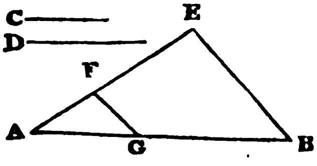
To find a mean proportional between two given right lines A *and* B.



Draw any right line CE and in it take CD equal A, and DE equal B; bisect CE in F, and with the centre F and radius FC or FE describe the semicircle CGE; draw DG perpendicular to CE: then DG will be a mean proportional between A and B.

PROBLEM XVI.

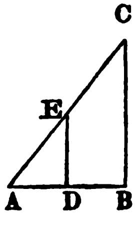
To divide a given right line AB *into two parts that shall have the same ratio to each other as two given lines* C *and* D.



Draw AE making an angle with AB; in AE take AF equal C and FE equal D: join EB and draw FG parallel to it; then AG will have to GB the same ratio that C has to D.

PROBLEM XVII.

To divide a given right line AB *in two parts in the point* D, *so that* AD *may be to* DB *in the ratio of two given numbers* m *and* n. *For example, let* $m=3$, *and* $n=4$.



Draw AC making any angle with AB; take the number m from any convenient scale of equal parts, and lay it on AC, from A to E; and take the number n from the same scale, and lay it from E to C; join CB and draw ED parallel to it; then AB will be divided as required.

PLANE TRIGONOMETRY.

DEFINITIONS.

1. Plane Trigonometry is the art by which, when any three parts of a plane triangle, except the three angles, are given, the others are determined.

2. The periphery of every circle is supposed to be divided into 360 equal parts, called degrees; each degree into 60 equal parts, called minutes; and each minute into 60 equal parts, called seconds, &c.

3. The measure of an angle is the arc of a circle, contained between the two lines that form the angle, the angular point being the centre; thus the angle ABC, Fig. 30, is measured by the arc DE, and contains the same number of degrees that the arc does. The measure of a right angle is therefore 90 degrees; for DH, Fig. 31, which measures the right angle DCH, is one fourth part of the circumference, or 90 degrees.

Note.—The degrees, minutes, seconds, &c. contained in any arc, or angle, are written in this manner, 50° 18′ 35″; which signifies that the given arc or angle contains 50 degrees 18 minutes and 35 seconds.

4. The *complement* of an arc, or of an angle, is what it wants of 90°; and the supplement of an arc, or of an angle, is what it wants of 180°.

5. The *chord* of an arc, is a right line drawn from one extremity of the arc to the other: thus the line BE is the chord of the arc BAE or BDE, Fig. 31

6. The *sine* of an arc, is a right line drawn from one extremity of the arc perpendicular to the diameter which passes through the other extremity: thus BF is the sine of the arc AB or BD, Fig. 31.

7. The *cosine* of an arc, is that part of the diameter which is intercepted between the sine and the centre: thus CF is the cosine of the arc AB, and is equal to BI, the sine of its complement HB, Fig. 31.

8. The *versed sine* of an arc, is that part of the diameter which is intercepted between the sine and the arc: thus AF is the versed sine of AB; and DF of DB, Fig. 31.

9. The *tangent* of an arc, is a right line touching the circle in one end of the arc, being perpendicular to the diameter which passes through that end, and is terminated by a right line drawn from the centre through the other end: thus AG is the tangent of the arc AB, Fig. 31.

10. The *secant* of an arc, is the right line drawn from the centre and terminating the tangent; thus CG is the secant of AB, Fig. 31.

11. The *cotangent* of an arc, is the tangent of the complement of that arc; thus HK is the cotangent of AB, Fig. 31.

12. The *cosecant* of an arc, is the secant of the complement of that arc; thus CK is the cosecant of AB, Fig. 31.

13. The sine, cosine, &c. of an *angle* is the same as the sine, cosine, &c. of the *arc* that measures the angle.

PROBLEM I.

To construct the lines of cords, sines, tangents, and secants, to any radius. Fig. 32.

Describe a semicircle with any convenient radius CB; from the centre C draw CD perpendicular to AB and produce it to F; draw BE parallel to CF and join AD.

Divide the arc AD into nine equal parts, as A 10; 10, 20, &c. and with one foot of the dividers in A, transfer the distances A, 10; A, 20, &c. to the right line AD; then will AD be a line of *chords* constructed to every ten degrees.

Divide BD into nine equal parts, and from the points of division, 10, 20, 30, &c. draw lines parallel to CB,[*] and meeting CD in 10, 20, 30, &c. and CD will be a line of *sines*.

From the centre C, through the divisions of the arc BD, draw lines meeting BE, in 10, 20, 30, &c. and BE will be a line of *tangents*.

With one foot of the dividers in C transfer the distances from C to 10, 20, &c. in the line BE to the line CF which will then be a line of *secants*.

By dividing the arcs AD and BD each into 90 equal parts, and proceeding as above, the lines of chords, sines, &c. may be constructed to every degree of the quadrant.

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[*] To avoid confusion, these lines are not drawn in the figure.

PROBLEM II.

At a given point A *in a given right line* AB, *to make an angle of any proposed number of degrees suppose* 38 *degrees.* Fig. 33.

With the centre A, and a radius equal to 60 degrees, taken from a scale of chords, describe an arc, cutting AB in *m*; from the same scale of chords, take 38 degrees and apply it to the arc from *m* to *n*, and from A through *n* draw the line AC; then will the angle A contain 38 degrees.

Note.—Angles of more than 90 degrees are taken off at twice.

PROBLEM III.

To measure a given angle A. Fig. 34.

Describe the arc *mn* with the chord of 60 degrees, as in the last problem. Take the arc *mn* between the dividers, and that extent applied to the scale of chords will show the degrees in the given angle.

Note.—When the distance *mn* exceeds 90 degrees, it must be taken off at twice, as before.

OF THE TABLE

OF

LOGARITHMIC OR ARTIFICIAL SINES, TANGENTS, &c.

THIS table contains the logarithms of the sine, tangent, &c. to every degree and minute of the quadrant, the radius being 10000000000, and consequently its logarithm 10.

Let the radius CB, Fig. 32, be supposed to consist of 10000000000 equal parts as above, and let the quadrant DB be divided into 5400 equal arcs, each of these will therefore contain 1′; and if from the several points of division in the quadrant, right lines be drawn perpendicular to CB, the sine of every minute of the quadrant to the radius CB will be exhibited. The lengths of these lines being computed and arranged in a table, constitute what is usually termed a table of *natural* sines. The logarithms of those numbers taken from a table of logarithms, and properly arranged, form the table of *logarithmic* or *artificial sines*. In like manner the logarithmic tangents and secants are to be understood.

The method by which the sines are computed is too abstruse to be explained in this work, but a familiar exposition of this subject, as well as of the construction of logarithms may be seen in *Simpson's trigonometry*.

To find, by the table, the sine, tangent, &c. of an arc or angle.

If the degrees in the given angle be less than 45, look for them at the top of the table, and for the minutes, in the left hand column; then in the column marked at the top of the table, sine, tangent, &c. and against the minutes, is the sine, tangent, &c. required. If the degrees are more than 45, look for them at the bottom of the table, and for the minutes, in the right hand column; then in the column marked at the bottom of the table, sine, tangent, &c. and against the minutes, is the sine, tangent, &c. required.

Note.—The sine of an angle and of its supplement being the same, if the given number of degrees be above 90, subtract them from 180°, and find the sine of the remainder.

EXAMPLES.

1. Required the sine of 32° 27′ *Ans.* 9.72962.
2. Required the tangent of 57° 39′ *Ans.* 10.19832.
3. What is the secant of 89° 31′ *Ans.* 12.07388.
4. What is the sine of 157° 43′ *Ans.* 9.57885.

To find the degrees and minutes corresponding to a given sine, tangent, &c.

Find, in the table, the nearest logarithm to the given one, and the degrees answering to it will be found at the top of the table, if the name be there, and the minutes on the left hand; but if the name be at the bottom of the table, the degrees must be found at the bottom, and the minutes at the right hand.

EXAMPLES.

1. Required the degrees and minutes in the angle whose sine is 9.64390. *Ans.* 26° 8′.

2. Required the degrees and minutes in the angle whose tangent is 10.47464. *Ans.* 71° 28′.

ON GUNTER'S SCALE.

Gunter's scale is an instrument by which, with a pair of dividers, the different cases in trigonometry, and many other problems, may be approximately solved.

It has on one side, a diagonal scale, and also the lines of chords, sines, tangents, and secants, with several others.

On the other side there are several logarithmic lines as follow:

The line of *numbers* marked *Num.*, is numbered from the left hand of the scale towards the right, with 1, 2, 3, 4, 5, 6, 7, 8, 9, 1, which stands in the middle of the scale; the numbers then go on 2, 3, 4, 5, 6, 7, 8, 9, 10, which stands at the right hand end of the scale. These two equal parts of the scale are similarly divided, the distances between the first 1, and the numbers 2, 3, 4, &c. being equal to the distances between the middle 1, and the numbers 2, 3, 4, &c. which follow it. The subdivisions of the two parts of this line are likewise similar, each primary division being divided into ten parts, distinguished by lines of about half the length of the primary divisions.

The primary divisions on the second part of the scale, are estimated according to the value set upon the unit on the left hand of the scale. If the first 1 be considered as a unit, then the first 1, 2, 3, &c. stand for 1, 2, 3, &c the middle 1 is 10, and the 2, 3, 4, &c. following stand for 20, 30, 40, &c. and the ten at the right hand for 100. If the first 1 stand for 10, the first 2, 3, 4, &c. must be counted 20, 30, 40, &c. the middle 1 will be 100, the second 2, 3, 4, &c. will stand for 200, 300, 400, &c. and the 10 at the right hand for 1000.

If the first 1 be considered as $\frac{1}{10}$ of a unit, the 2, 3, 4, &c. following will be $\frac{2}{10}$, $\frac{3}{10}$, $\frac{4}{10}$, &c. and the middle 1, and the 2, 3, 4, &c. following, will stand for 1, 2, 3, 4, &c.

The intermediate small divisions must be estimated according to the value set upon the primary divisions.

Sines.—The line of sines, marked *Sin.*, is numbered from the left hand of the scale towards the right, 1, 2, 3, 4, &c. to 10, then 20, 30, 40, &c. to 90, where it terminates just opposite 10 on the line of numbers.

Tangents.—The line of tangents, marked *Tan.*, begins at the left hand, and is numbered 1, 2, 3, &c. to 10, then 20, 30, 40, 45, where there is a brass pin, just under 90 in the line of sines; because the sine of 90° is equal to the tangent of 45°. From 45 it is numbered towards the left hand 50, 60, 70, 80, &c. The tangent arcs of above 45° are therefore counted backward on the line, and are found at the same points of the line as the tangents of their complements.

There are several other lines on this side of the scale, as *Sine Rhumbs*, *Tangent Rhumbs*, *Versed Sines*, &c.; but those described are sufficient for solving all the problems in plane trigonometry.

Remarks on Angles, Triangles, &c.

1. If from a point D in a right line AB, one or more right lines be drawn on the same side of it, the angles thus formed at the point D will be together equal to two

right angles, or 180°; thus ADE+EDB=two right angles, or 180°: also ADC+CDE+EDB=two right angles, or 180°. Fig. 35.

2. Since the angles thus formed at the point D, on the other side of AB, would also be equal to two right angles, the sum of all the angles formed about a point is equal to four right angles or 360°.

3. If two right lines cut one another, the opposite angles will be equal: thus AEC=BED, and AED=CEB. Fig. 36.

4. The sum of the three angles of a plane triangle is equal to two right angles, or 180°.

5. If the sum of two angles of a triangle be subtracted from 180°, the remainder will be the third angle.

6. If one angle of a triangle be subtracted from 180°, the remainder will be the sum of the other two angles.

7. In right-angled triangles, if one of the acute angles be subtracted from 90°, the remainder will be the other acute angle.

8. The angles at the base of an isosceles triangle are equal to one another.

9. If one side of a triangle be produced, the external angle will be equal to the sum of the two internal and opposite angles: thus the external angle CBD, of the triangle ABC, is equal to the sum of the internal and opposite angles A and C. Fig. 37.

10. The angle at the centre of a circle is double of the angle at the circumference, upon the same base, that is upon the same part of the circumference: thus the angle BEC is double of the angle BAC. Fig. 38.

11. The angles in the same segment of a circle are equal to one another: thus the angle BAD is equal to the angle BED; also the angle BCD is equal to the angle BFD. Fig. 39.

12. The angle in a semicircle is a right angle: thus the angle ECF, Fig. 45, is a right angle.

13. This mark ′ placed on the sides or in the angles of a triangle, indicates that they are given; and this mark ° placed in the same way, indicates that they are required.

PRACTICAL RULES FOR SOLVING ALL THE CASES OF PLANE TRIGONOMETRY.

CASE 1.

The angles and one side of any plane triangle being given, to find the other sides.

RULE.

As the sine of the angle opposite the given side,
Is to the sine of the angle opposite the required side,
So is the given side,
To the required side.*

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* DEMONSTRATION. Let ABC, Fig. 40, be any plane triangle; take BF=AC and upon AB let fall the perpendiculars CD and FE, which will be the sines of

Note 1.—The proportions in trigonometry are worked by logarithms: thus, from the sum of the logarithms of the second and third terms, subtract the logarithm of the first term, and the remainder will be the logarithm of the fourth term.

2. The logarithmic sine of a right angle or 90° is 10.00000, being the same as the logarithm of the radius.

EXAMPLES.

1. In the triangle ABC, there are given the angle $A=32° 15'$, the angle $B=114° 24'$, and consequently the angle $C=33° 21'$ and the sides $AB=98$;* required the sides AC and BC.

By Construction, Fig. 41.

Make AB equal to 98 by a scale of equal parts, and draw AC, making the angle $A=32° 15'$; also make the angle $B=114° 24'$ and produce BC, AC, till they meet in C, then is ABC the triangle required; and AC measured by the same scale of equal parts, is 162, and BC is 95.

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the angles A and B to the equal radii AC and BF. Now the triangles BDC and BEF being similar, we have CD : FE : : BC : BF : or AC; that is sin. A : sin. B : : BC : AC. In like manner it is proved, that sin. A : sin. C : : BC : AB. When one of the angles is obtuse, the demonstration is the same. Hence it appears, that in any plane triangle, the sides are to one another as the sines of their opposite angles.

* This 98 may express so many feet, or yards, &c., and the other sides will be of the same denomination as the given.

By Calculation.

As sine of the angle C 33° 21′ - -	9.74017
Is to sine of the angle B 114° 24′ - -	9.95937
So is AB 98 - - - - - - -	1.99123
	11.95060
	9.74017
To AC 162.3 - - - - - - - -	2.21043
As sine of C 33° 21′ - - - - - -	9.74017
Is to sine of A 32° 15′ - - - - - -	9.72723
So is AB 98 - - - - - - - -	1.99123
	11.71846
	9.74017
To BC 95.12 - - - - - - - -	1.97829

By Gunter's Scale.

Extend the compasses, on the line of sines, from 33° 21′ to 65° 36′ the supplement of the angle B; that extent will reach, on the line of numbers, from 98 to 162, the side AC.

Extend the compasses from 33° 21′ to 32° 15′ on the line of sines; that extent will reach, on the line of numbers, from 98 to 95, the side BC.

2. In the right-angled triangle ABC, are given the hypothenuse AC=480, and the angle A=53° 8′. To find the base AB and perpendicular BC.

From 90° subtract the angle A=53° 8′; the remainder 36° 52′ will be the angle C. The angle B, being a right angle, is 90°.

By Construction, Fig. 42.

This may be constructed as in the preceding example, or otherwise thus,

Draw the line AB of any length, and draw AC making the angle A=53° 8′; make AC=480 by a scale of equal parts, and from C draw CB perpendicular to AB, then ABC is the triangle required. AB measured by the same scale of equal parts, will be 288, and BC will be 384.

By Calculation.

As sine of B 90° - - - - - -	10.00000
Is to sine of A 53° 8′ - - - - -	9.90311
So is AC 480 - - - - - - -	2.68124
	12.58435
To BC 384 - - - - - - - -	2.58435
As sine of B 90° - - - - - - -	10.00000
Is to sine of C 36° 52′ - - - -	9.77812
So is AC 480 - - - -	2.68124
	12.45936
To AB 288 - - - - - - - -	2.45936

By Gunter's Scale.

Extend the compasses, on the line of sines, from 90° to 53° 8′, that extent will reach, on the line of numbers, from 480 to 384 the perpendicular BC.

Extend the compasses, on the line of sines, from 90° to 36° 52′, the complement of the angle A; that extent will reach, on the line of numbers, from 480 to 288, the base AB.

3. In the triangle ABC, are given the angle A=79° 23′, the angle B=54° 22′, and the side BC=125; required AC and AB. *Ans.* AC=103.4, and AB=91.87.

4. In a right-angled triangle, there are given the angle A=56° 48′, and the base AB=53.66, to find the perpendicular BC and hypothenuse AC. *Ans.* BC=82 and AC=98.

5. In the right-angled triangle ABC, are given the angle A=39° 10′, and the perpendicular BC=407.37, to find the base AB and hypothenuse AC. *Ans.* AB = 500.1, and AC=645.

CASE 2.

Two sides and an angle opposite one of them being given, to find the other angles and side.

RULE.

As the side opposite the given angle,
Is to the other given side,
So is the sine of the angle opposite the former,
To the sine of the angle opposite the latter.[*]

---

[*] This is evident from the demonstration of the rule in the preceding case

Add the angle thus found to the given angle, and subtract their sum from 180°, the remainder will be the third angle.

After finding the angles, the other side may be found by Case 1.

Note.—The angle found by this rule is sometimes ambiguous; for the operation only gives the sine of the angle, not the angle itself; and the sine of every angle is also the sine of its supplement.

When the side opposite the given angle is equal to, or greater than the other given side, then the angle opposite that other given side is always acute; but when this is not the case, that angle may be either acute or obtuse, and is consequently ambiguous

EXAMPLES.

1. In the triangle ABC, are given the angle C=33° 21′, the side AB=.98 and the side BC=.7912; required the angles A and B, and the side BC.

By Construction, Fig. 43.

Make BC=.7912 by a scale of equal parts, and draw CA, making the angle C=33° 21′; with the side AB=.98, in the compasses, taken from the same scale of equal parts, and B as a centre, describe the arc *ab*, cutting AC in the point A, and join BA; then is ABC the triangle required: the side AC, measured by the scale of equal parts will be 1.54, and the angles A and B, measured by a scale of chords will be 26° 21′ and 120° 18′.

Here the arc *ab* cuts AC in one point only, because AB is greater than BC; therefore the angle A is acute, and not ambiguous.

By Calculation.

As AB, .98	—1.99123
Is to BC, .7912	—1.89829
So is sine of C, 33° 21′	9.74017
	9.63846
To sine of A, 26° 21′	9.64723

To the angle C=33° 21′ add the angle A=26° 21′ and the sum is 59° 42′ which subtracted from 180° leaves the angle B=120° 18′

As sine of C, 33° 21′	9.74017
Is to sine of B, 120° 18′.	9.93621
So is AB, .98	—1.99123
	9.92744
To AC, 1.539	0.18727

By Gunter's Scale.

Extend the compasses from .98 to .79 on the line of numbers, that extent will reach from 33° 21′ to 26° 21′, the angle A, on the line of sines.

Add the angle A=26° 21′ to the angle C=33° 21′, and the sum will be 59° 42′; then extend the compasses from 33° 21′ to 59° 42′, on the line of sines, that extent will reach from .98 to 1.54, the side AC, on the line of numbers.

2. In the triangle ABC, are given the angle C=33° 21′, the side BC=95.12 and the side AB=60, to find the angles A and B, and the side AC.

By Construction, Fig. 44.

This is constructed in the same manner as the preceding example; only AB, being shorter than BC, the arc *ab* cuts AC in two points on the same side of BC; hence the angle A may be either acute or obtuse. The side required has also two values, as AC and AC.

By Calculation.

As AB, 60 - - - - - - - -	1.77815
Is to BC, 95.12 - - - - - - -	1.97827
So is sine C, 33° 21′ - - - - -	9.74017
	11.71844
To sine of A $\left\{\begin{array}{l}60° 38' \text{ acute} \\ 119\ 22 \text{ obtuse}\end{array}\right\}$	9.94029

The sum of the angles C and A subtracted from 180° leaves the angle B=86° 1′ if A be acute, or 27° 17′ if A be obtuse.

To find the side AC answering to the acute value of the angle A.

As sine of C, 33° 21′ - - -	9.74017
Is to sine of B, 86° 1′ - - - -	9.99895
So is AB, 60 - - - - - -	1.77815
	11.77710
To AC, 108.9 - - - - - -	2.03698

To find the side AC, answering to the obtuse value of the angle A.

As sine of C, 33° 21′ - - -	9.74017
Is to sine of B, 27° 17 - - -	9.66124
So is AB, 60 - - - -	1.77815
	11.43939
To AC, 50.03 - - - - -	1.69922

3. In a triangle ABC, the side AB is 274, AC 306, and the angle B 78° 13′; required the angles A and C, and the side BC.

Ans. A=40° 33′, C=61° 14′, and BC=203.2.

4. In a right-angled triangle, there are given the hypothenuse AC=272, and the base AB=232; to find the angles A and C, and the perpendicular BC.

Ans. A=31° 28′ C=58° 32′ and BC=142.

5. In a right-angled triangle ABC, the hypothenuse AC is 150, and one side BC 69; required the angles and other side.

Ans. C=62° 37′, A=27° 23′, and AB 133.2.

CASE 3.

Two sides and the included angle being given, to find the other angles and side.

RULE.

Subtract the given angle from 180°, and the remainder will be the sum of the two unknown angles. Then,

As the sum of the two given sides,
Is to their difference;

So is the tangent of half the sum of the two unknown angles,
To the tangent of half their difference.*

This half difference of the two unknown angles, added to their half sum, will give the angle opposite the greater of the two given sides, and being subtracted from the half sum will give the angle opposite the less given side.

---

* DEMONSTRATION. Let ABC, Fig. 45, be the proposed triangle, having the two given sides AB, AC, including the given angle A. About A as a centre, with AC the greater of the given sides for a radius, describe a circle meeting AB produced in E and F, and BC in D; join DA, EC, and FC, and draw FG parallel to BC, meeting EC produced in G.

The angle EAC (32.1.) is equal to the sum of the unknown angles ABC, ACB; and the angle EFC at the circumference, is equal to the half of EAC at the centre (20.3.;) therefore EFC is half the sum of the unknown angles; but (32.1.) the angle ABC is equal to the sum of the angles BAD and ADB or BAD and ACB; therefore FAD is the difference of the unknown angles ABC, ACB; and FCD, at the circumference is the half of that difference; but because of the parallels DC, FG, the angles GFC, FCD are equal; therefore GFC is equal to half the difference of the unknown angles ABC, ACB; but since the angle ECF in a semicircle, is a right angle, EG is perpendicular to CF, and therefore CF being radius, EC, CG are the tangents of the angles EFC, CFG; it is also evident that EB is the sum of the sides BA, AC, and that BF is the difference; therefore since BC, FG are parallel, EB : BF :: EC : CG (2.6.:) that is, the sum of the sides AC, AB, is to their difference, as the tangent of half the sum of the angles ABC, ACB, is to the tangent of half their difference.

To demonstrate the latter part of the rule, let AC and AB, Fig. 46, represent any two magnitudes whatever; in AB produced, take BD equal to AC the less, and bisect AD in E.

Then because AE is equal to ED and AC to BD, CE is equal to EB; therefore AE or ED is half the sum of the given magnitudes AB, AC, and CE or EB is half their difference; but AB the greater is equal to AE, EB, that is to half the sum added to half the difference; and AC the less, is equal to the excess of AE, half the sum, above CE, half the difference.

After finding the angles, the other side may be found by Case 1.

EXAMPLES.

1. In the triangle ABC, there are given AB=128, AC=90, and the angle A=48° 12′, to find the angles B and C, and the side BC.

By Construction, Fig. 47.

Draw AB=128, and make the angle A=48° 12′; draw AC=90, and join BC. The angle B will measure 44° 37′, the angle C 87° 11′, and the side BC 95.5.

By Calculation.

AB	128		180°	0′
AC	90	Angle A - - - - -	48	12
Sum	218	Sum of the angles B and C	131	48
Difference	38	Half sum do.	65	54

As the sum of the sides, AB, AC, 218 - - 2.33846

Is to their difference, 38 - - - - - - - 1.57978

So is the tangent of half the sum of the angles B and C, 65° 54′ } 10.34938

11.92916

To tang. of half their difference, 21° 17′ - - 9.59070

Half sum of the angles B and C - - - 65° 54′

Add and subtract half their difference - 21 17

Angle C - - - - - - 87 11

Angle B - - - - - - - - - - 44 37

To find the side BC.

As sine of B, 44° 37′ - - - 9.84656
Is to sine of A, 48 12 - - - 9.87243
So is AC, 90 - - - 1.95424

11.82667

To BC, 95.52 - - - - - 1.98011

By Gunter's Scale.

Extend the compasses from 218, the sum of the sides, to 38, their difference, on the line of numbers, and apply this extent to the line of tangents from 45° to the left hand; then keeping the left leg of the compasses fixed, move the other leg to 65° 54′ the half sum of the angles; that distance will reach from 45° on the same line, to 21° 17′, the half difference of the required angles. Whence the angles are obtained as before.

To extend the second proportion, proceed as directed in Case 1st.

2. In a triangle ABC, are given AB=109, BC=76, and the contained angle B=101° 30′, to find the other angles and side.

Ans. The angle A=30° 57′, C=47° 33′, and the side AC=144.8.

3. Given, in a right-angled triangle, the base AB=890 and the perpendicular BC=787, to find the angles and hypothenuse.

Ans. The angle A=41° 29′, C=48° 31′, and the hypothenuse AC=1188.

CASE 4.

Given the three sides, to find the angles.

RULE 1.

Consider the longest side of the triangle as the base, and on it let fall a perpendicular from the opposite angle. This perpendicular will divide the base into two parts, called segments, and the whole triangle into two right-angled triangles. Then,

As the base, or sum of the segments,
Is to the sum of the other two sides;
So is the difference of those sides,
To the difference of the segments of the base.*

---

* **Demonstration.** Let ABC, Fig. 48, be a triangle, and CD be perpendicular upon AB. About C as a centre with the less side BC for a radius, describe a circle, meeting AC produced, in G and E, and AB in F. Then it is evident that AE is equal to the sum of the sides AC, BC, and that AG is equal to their difference; also because CD bisects FB (3.3,) it is plain that AF is the difference of the segments of the base; but A×BAF=AE × AG (36.3. cor.;) therefore AB : AE : : AG : AF (16.6;) that is, the base, is to the sum of the sides, as the difference of the sides, is to the difference of the segments of the base.

Cor. If AF be considered the base of the triangle AFC, then will CD be a perpendicular on the base produced; AE will be equal to the sum of the sides AC, FC, and AG will be equal to their difference; also AB will be equal to the sum of the segments AD, FD. But by the preceding demonstration and (16.5,) AF : AE : : AG : AB; hence, when the perpendicular falls without the triangle, the base is to the sum of the sides, as the difference of the sides is to the sum of the segments of the base.

A rule might, therefore, be given, making either side of a triangle the base; and such a rule would be rather more convenient, in some cases, than the one above: but then, on account of the perpendicular sometimes falling within and sometimes without the triangle, it would require two cases, and consequently would be less simple.

To half the base, add half the difference of the segments, and the sum will be the greater segment; also from half the base, subtract half the difference of the segments, and the remainder will be the less segment.

Then, in each of the two right-angled triangles, there will be known two sides, and an angle opposite to one of them; consequently the other angles may be found by Case 2.

1. In the triangle ABC, are given AB=426, AC=365, and BC=230; required the angles.

By Construction, Fig. 49.

Draw AB=426; with AC=365 in the dividers, and one foot in A, describe an arc, and with BC=230, and one foot in B describe another arc, cutting the former in C; join AC, BC, and ABC will be the triangle required. The angles measured by a scale of chords, will be A=32° 39′, B=58° 56′, and C=88° 25′.

By Calculation.

AC - - - - - - -	365
BC - - - - - - -	230
Sum - - - - - - -	595
Difference - - - -	135

As the base AB	426	2.62941
Is to the sum of the sides AC, BC	595	2.77452
So is the diff. of the sides AC, BC	135	2.13033
		4.90485
To the diff. of the segments AD, DB	188.6	2.27544
Half diff. of the segments	94.3	
Half base	213.	
Segment AD	307.3	
Segment BD	118.7	

As AC	365	2.56229
Is to AD	307.3	2.48756
So is sine of ADC	90°	10.00000
		12.48756
To sine of ACD	57° 21′	9.92527
	90 00	
Angle A	32 39	

As BC	230	2.36173
Is to BD	118.7	2.07445
So is sine of BDC	90°	10.00000
		12.07445
To sine of BCD	31° 4′	9.71272
	90 0	
Angle B	58 56	

From 180° subtract the sum of the angles A, and B. 91° 35′, and the remainder 88° 25′ is the angle C.

By Gunter's Scale.

Extend the compasses from 426 to 595 on the line ot numbers; that extent will reach on the same line from 135 to 188.6 the difference of the segments of the base. Whence the segments of the base are found as before. To extend the other proportions, proceed as directed in Case 2.

2. In a triangle ABC, there are given AB=64, AC=47, and BC=34; required the angles. *Ans.* Angle A =31° 9′, B=45° 38′, and C=103° 13′.

3. In a triangle ABC, are given AC=88, AB=108, and BC=54, to find the angles. *Ans.* Angle A=29° 49′, B=54° 7′, and C=96° 4′.

RULE 2.

Add together the arithmetical complements of the logarithms of the two sides containing the required angle, the logarithm of the half sum of the three sides, and the logarithm of the difference between the half sum and the side opposite the required angle. Then half the sum of these four logarithms will be the logarithmic cosine of half the required angle.*

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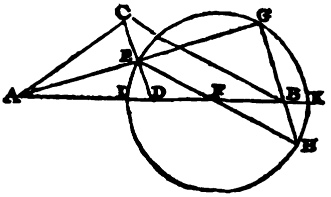
* DEMONSTRATION. Let ABC, be a triangle of which the side AB, is greater than AC: make AD=AC, join DC, bisect it in E, and join AE; draw EH parallel and equal to CB; join HB and produce it to meet AE produced in G.

Now in the triangles AED, AEC, all the sides of the one are equal to the sides of the other, each to each; therefore (8.1) the angle EAD =EAC, and AED=AEC; consequently AED is a right angle.



EXAMPLES.

1. In the triangle ABC, are given AB=426, AC=365 and BC=230; required the angle A.

By Calculation.

BC	230		
AC	365	Ar. Co.	7.43771
AB	426	Ar. Co.	7.37059
	2)1021		
Half sum	510.5	log.	2.70800
Difference	280.5	log.	2.44793
			2)19.96423
Cos. ½ A	16° 20′		9.98211
	2		
Angle A	32 40		

Because EH is equal and parallel to BC, BH is also equal and parallel to EC (33.1;) now in the triangles EDF and HBF, the angle EFD=BFH, the angle FED=FHB (29.1) and ED=EC=BH; therefore (26.1) EF=FH, and FD=FB. Again, the angle HGE=DEA=a right angle; if therefore with the centre F, and radius FE=FH, a circle be described, it will pass through the point G (31.3.)

Now 2AF=2AD+2DF=AD+AD+DB=AD+AB=AC+AB; therefore AF=½AC+½AB; also FK=½IK=½EH=½BC; hence, by adding equals to equals, AF+FK=½AC+½AB+½BC, or AK=½(AC+AB+BC;) again, AI=AK—IK=½(AC+AB+BC)—BC.

But (Dem. to rule, case 1st.) AD : AE : : sin. AED : sin. ADE : : rad. : cos. EAD (cos. ½BAC.) Also, AB : AG : : sin. AGB : sin. ABG : : rad. : cos. BAG (cos. ½BAC.)

Hence (c. 6) AB×AD : : AG×AE : : rad.^2 : $(\text{cos. }\tfrac{1}{2}\text{BAC})^2$. But AB×AD=AB×AC, and (cor. 36.3) AG×AE=AK×AI=½(AC+AB+BC)×[½(AC+AB+BC)—BC;] therefore AB×AC: ½(AC+AB+BC)×[½(AC+AB+BC)—BC] : : rad.^2 : $(\text{cos. }\tfrac{1}{2}\text{BAC})^2$.

Now it is evident, that in working this proportion by logarithms

If the other angles are required, they may be found by Case 1.

2. In a triangle ABC, are given AB=64, AC=47, and BC=34, to find the angle B. *Ans.* Angle B=45° 38′.

3. In a triangle ABC, are given AC=88, AB=108, and BC=54, to find the angle C. *Ans.* C=96° 4′.

The preceding rules solve all the cases of plane triangles, both right-angled and oblique. There are, however, other rules, suited to right-angled triangles, which are sometimes more convenient than the general ones. Previous to giving these rules, it will be necessary to make the following

Remarks on right-angled triangles.

1. ABC, Fig. 50, being a right-angled triangle, make one leg AB radius, that is, with the centre A, and distance AB describe an arc BF. Then it is evident that the other leg BC represents the tangent of the arc BF, or of the angle A, and the hypothenuse AC the secant of it.

2. In like manner, if the leg BC, Fig. 51, be made radius; then the other leg AB will represent the tangent of the arc BG, or angle C, and the hypothenuse AC the secant of it.

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and taking the arithmetical complements of the logarithms of the first term, viz. of the two sides including the required angle, if we omit the logarithm of the square of radius, which is 20, it is just equivalent to rejecting 20 from the sum of the logarithms; which would otherwise have to be done.

3. But if the hypothenuse be made radius, then each leg will represent the sine of its opposite angle; namely, the leg AB, Fig. 52, the sine of the arc AE or angle C, and the leg BC the sine of the arc CD, or angle A.

The angles and one side of a right-angled triangle being given, to find the other sides.

RULE.

Call any one of the sides radius, and write upon it the word radius; observe whether the other sides become sines, tangents, or secants, and write these words on them accordingly. Call the word written upon each side the name of that side. Then,

As the name of the side given,
Is to the name of the side required;
So is the side given,
To the side required.*

Two sides of a right-angled triangle being given to find the angles and other side.

RULE.

Call either of the given sides radius, and write on them as before. Then,

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* **Demonstration.** Let ABC, Fig. 53, be a right angled triangle; then it is evident that BC is the tangent, and AC the secant of the angle A, to the radius AB. Let AD represent the radius of the tables, and draw DE perpendicular to AD, meeting AC produced in E; then DE is the tangent, and AE the secant of the angle A, to the radius AD. But because of the similar triangles ADE, ABC, AD : DE : : AB : BC; that is, the tabular radius : tabular tangent : : AB : BC. Also AD : AE : : AB : AC; that is, the tabular radius : tabular secant : : AB : AC. These proportions correspond with the rule. When either of the other sides is made radius, the demonstration will be similar.

As the side made radius,
Is to the other given side;
So is radius,
To the name of that other side.*

After finding the angle, the other side is found as in the preceding rule.

EXAMPLES.

1. In a right-angled triangle ABC, are given the base AB=208, and the angle A=35° 16′, to find the hypothenuse AC and perpendicular BC.

By Calculation.

The hypothenuse AC being radius.

As the sine of C, 54° 44′ - - - -	9.91194
Is to radius - - - - - - -	10.00000
So is AB 208 - - - - - - -	2.31806
	12.31806
To AC 254.8 - - - - - - -	2.40612
As the sine of C 54° 44′ - - - -	9.91194
Is to the sine of A, 35 16 - - - -	9.76146
So is AB 208 - - - - - - -	2.31806
	12.07952
To BC, 147.1 - - - - - - -	2.16758

---

* This is the converse of the preceding rule.

The base AB being radius.

As radius - - - - - - - - - -	10.00000
Is to the secant of A, 35° 16′ - -	10.08806
So is AB 208 - - - - - - -	2.31806
	12.40612
To AC 254.8 - - - - -	2.40612

As radius - - - - - - - -	10.00000
Is to tangent of A, 35° 16′ - -	9.84952
So is AB, 208 - - - - - - -	2.31806
	12.16758
To BC 147.1 - - - - - - - - -	2.16758

The perpendicular BC being radius.

As tangent of C 54° 44′ - - - -	10.15048
Is to secant of C, 54 44 - - - -	10.23854
So is AB, 208 - - - - - - - -	2.31806
	12.55660
To AC 254.8 - - - - - - - - -	2.40612

As tangent of C, 54° 44′ - - - -	10.15048
Is to radius, - - - - - - - - -	10.00000
So is AB 208 - - - - - - -	2.31806
	12.31806
To BC, 147.1 - - - - -	2.16758

2. In a right-angled triangle ABC, there are given the hypothenuse AC=272, and the base AB=232; required the angles A and C, and the perpendicular BC.

By Calculation.

The hypothenuse AC being radius.

As AC, 272 - - - - - - - - - 2.43457
Is to AB, 232 - - - - - - - - - 2.36549
So is radius - - - - - - - - - 10.00000

12.36549

To sine of C, 58° 32′ - - - - 9.93092

As radius - - - - - - - - - 10.00000
Is to sine of A, 31° 28′ - - - - 9.71767
So is AC, 272 - - - - - - - - - 2.43457

12.15224

To BC, 142 - - - - - - - 2.15224

The base AB being radius.

As AB, 232 - - - - - - - - - 2.36549
Is to AC, 272 - - - - - - - - - 2.43457
So is radius - - - - - - - - - 10.00000

12.43457

To secant of A, 31° 28′ - - - - - 10.06908

As radius - - - - - - - - - 10.00000
Is to tangent of A, 31° 28′ - - - 9.78675
So is AB, 232 - - - - - - - 2.36549

12.15224

To BC, 142 - - - - - - - - - 2.15224

3. In a right-angled triangle, are given the hypothenuse AC=36.57, and the angle A=27° 46′, to find the base AB, and perpendicular BC.

Ans. Base AB=32.36, and perpendicular BC=17.04.

4. In a right-angled triangle, there are given, the perpendicular=193.6, and the angle opposite the base 47° 51′; required the hypothenuse and base.

Ans. Hypothenuse=288.5, and base=213.9.

5. Required the angles and hypothenuse of a right-angled triangle, the base of which is 46.72, and perpendicular 57.9.

Ans. Angle opposite the base 38° 54′, angle opposite the perpendicular 51° 6′, and hypothenuse 74.4.

When two sides of a right-angled triangle are given, the other side may be found by the following rules, without first finding the angles.

1. *When the hypothenuse and one leg are given, to find the other leg.*

RULE.

Subtract the square of the given leg from the square of the hypothenuse; the square root of the remainder will be the leg required.* Or by logarithms thus,

To the logarithm of the sum of the hypothenuse and given side, add the logarithm of their difference; half this sum will be the logarithm of the leg required.

---

* DEMONSTRATION. The square of the hypothenuse of a right-angled triangle is equal to the sum of the squares of the sides (47.1.) Therefore the truth of the first part of each of the rules is evident.

2. *When the two legs are given to find the hypothenuse.*

RULE.

Add together the squares of the two given legs; the square root of the sum will be the hypothenuse.* Or by logarithms thus,

From twice the logarithm of the perpendicular, subtract the logarithm of the base, and add the corresponding natural number to the base; then, half the sum of the logarithms of this sum, and of the base, will be the logarithm of the hypothenuse.

EXAMPLES.

1. The hypothenuse of a right-angled triangle is 272, and the base 232; required the perpendicular.

Calculation by logarithms.

Hypothenuse - -	272		
Base - - - -	232		
Sum - - - -	504	log.	2.70243
Difference - - -	40	——	1.60206
			2)4.30449
Perpendicular - -	142	——	2.15224

---

* Put h=the hypothenuse, b=the base, and p=the perpendicular, then (47.1) $p^2=h^2-b^2=$(5.2 cor.) $\overline{h+b}\times\overline{h-b}$, or $p=\sqrt{\overline{h+b}\times\overline{h-b}}$; whence, from the nature of logarithms, the latter part of the first rule is evident.

Also (47.1) $h^2=b^2+p^2=b\times\overline{b+\frac{p^2}{b}}$ or $h=\sqrt{\left(b\times\overline{b+\frac{p^2}{b}}\right)}$ which, solved by logarithmus, will correspond with the latter part of the second rule.

2. Given the base 186, and the perpendicular 152, to find the hypothenuse.

Calculation by Logarithms.

Perpendicular	152	log. 2.18184	
		2	
		4.36368	
Base - - -	186	2.26951	2.26951
	124.2	2.09417	
	310.2		log. .249164
			2)4.76115
Hypothenuse	240.2		log. 2.38057

3. The hypothenuse being given equal 403, and one leg 321; required the other leg. *Ans.* 243.7.

4. What is the hypothenuse of a right-angled triangle, the base of which is 31.04, and perpendicular 27.2? *Ans.* 41.27.

The following examples, in which trigonometry is applied to the mensuration of inaccessible distances and heights, will serve to render the student expert in solving the different cases, and also to elucidate its use.

THE APPLICATION OF PLANE TRIGONOMETRY TO THE MENSURATION OF DISTANCES AND HEIGHTS.

EXAMPLE 1, Fig. 54.

Being on one side of a river and wanting to know the distance to a house on the other side, I measured 500 yards along the side of the river in a right line AB, and found the two angles* between this line and the object to be CAB=74° 14′, and CBA=49° 23′. Required the distance between each station and the object.

Calculation.

The sum of the angles CAB and CBA is 123° 37′, which subtracted from 180° leaves the angle ACB=56° 23′ Then by Case 1;

s. ACB	:	s. CBA	: :	AB	:	AC
56° 23′		49° 23′		500		455.8

and

s. ACB	:	s. CAB	: :	AB	:	BC
56° 23′		74° 14′		500		577.8

EXAMPLE 2, Fig. 55.

Suppose I want to know the distance between two places A and B, accessible at both ends of the line AB, and that I measured AC=735 yards, and BC=840; also the angle ACB=55° 40′. What is the distance between A and B?

Calculation.

The Angle ACB=55° 40′, being subtracted from 180°, leaves 124° 20′; the half of which is 62° 10′. Then by Case 3.

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* The angles may be taken with a common surveyor's compass; or more accurately with an instrument called a theodolite.

$$\begin{array}{ccccccc} BC+AC & : & BC-AC & :: & \text{tangent}\,\frac{CAB+CBA}{2} & : & \text{tangent}\,\frac{CAB-CBA}{2} \\ 1575 & & 105 & & 62^\circ\,10' & & 7^\circ\,12' \end{array}$$

To and from $\frac{CAB+CBA}{2}=62^\circ\,10'$, add and sub. $\frac{CAB-CBA}{2}=7^\circ\,12'$, and we shall have CAB=69° 22′, and CBA=54° 58′. Then,

$$\begin{array}{ccccccc} s.\ ABC & . & s.\ ACB & :: & AC & : & AB \\ 54^\circ\,58' & & 55^\circ\,40' & & 735 & & 741.2 \end{array}$$

EXAMPLE 3, Fig. 56.

Wanting to know the distance between two inaccessible objects A and B, I measured a base line CD=300 yards: at C the angle BCD was 58° 20′ and ACD 95° 20′; at D the angle CDA was 53° 30′ and CDB 98° 45′. Required the distance AB.

Calculation.

1. In the triangle ACD, are given the angles ACD=95° 20′, ADC=53° 30′, and the side CD=300, to find AC=465.98.

2. In the triangle BCD, are given the angle BCD=58° 20′, BDC=98° 45′, and side CD=300, to find BC=761.47.

3. In the triangle ACB we have now given the angle ACB=ACD−BCD=37°, the side AC=465.98 and BC=761.47, to find AB=479.8 yards, the distance required.

EXAMPLE 4, Fig. 57.

Being on one side of a river and observing three objects, A, B and C stand on the other side, whose distances apart I knew to be, AB=3 miles, AC=2, and BC =1.8, I took a station D, in a straight line with the objects A and C, being nearer the former, and found the angle ADB=17° 47′. Required my distance from each of the objects.

Construction.

With the three given distances, describe the triangle ABC; from B, draw BE parallel to CA, and draw BD making the angle EBD=17° 47′ (the given angle ADB) and meeting CA produced, in D: then AD, CD and BD will be the distances required.*

Calculation.

1. In the triangle ABC we have all the sides given, to find the angle C=104° 8′.

2. Subtract the sum of the angles D and C from 180°, the remainder 58° 5′ will be the angle DBC; then in the triangle BCD we know all the angles and the side BC to find DC=5.002 and BD=5.715; therefore DA=DC—AC=3.002.

EXAMPLE 5, Fig. 58.

From a station at D, I perceived three objects, A, B and C, whose distances from each other I knew to be as follow: AB=12 miles, BC=7.2 miles, and AC=8 miles; at D, I took the angle CDB=25° and ADC=19°. Hence it is required to find my distance from each of the objects.

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* DEMONSTRATION. By construction, the distances AB, BC and AC are equal to the given distances; also the angle (29.1) BDC=the angle DBE=the given angle.

Construction.

With the given distances describe the triangle ABC; at B, make the angle EBA=19°=the given angle ADC, and at A, make the angle EAB=25°=the given angle BDC; draw AE, and BE meeting in E, and (by prob. 10,) describe a circle that shall pass through the points A, E and B: join CE and produce it to meet the circle in D, and join AD, BD, then will AD, CD, and BD be the distances required.*

Calculation.

1. In the triangle ABC, all the sides are given, to find the angle BAC=35° 35′.

2. In the triangle AEB, are given all the angles, viz. EAB=25°, EBA=19°, and AEB=136°, and the side AB=12, to find AE=5.624.

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* Demonstration. The angle ADC standing on the same arc with the angle ABE is equal to it (21.3.) For the same reason the angle BDC is equal to the angle BAE; but by construction the angles ABE and BAE are equal to the given angles; therefore the angles ADC and BDC are equal to the given angles.

Note.—When the given angles ADC, BDC are respectively equal to the angles ABC, BAC, the point E will fall on the point C, the circle will pass through the points A, C, and B, and the point D may be any where in the arc ADB; consequently, in this case, the situation of the point D, or its distance from each of the objects A, B, C, cannot be determined from the data given.

It may not be improper also to observe, that even when the angle ADB, which is the sum of the given angles, is equal to the sum of the angles ABC, BAC, or which is the same thing, is the supplement of the angle ACB, the circle passes through the points A, C, B; but then the angles ADC, BDC, unless they have been erroneously taken, will be respectively equal to the angles ABC, BAC.

3. In the triangle CAE we have given the side AC=8, AE=5.624, and the angle CAE=BAC—EAB=10° 35′ to find the angle ACE=22° 41′.

4. In the triangle DAC, all the angles are given, viz. ADC=19°, ACD=22° 41′ and CAD=180°—the sum of the angles ADC and ACD=138° 19′, and the side AC =8, to find AD=9.47 miles, and CD=16.34.

In the triangle ABD, we have the angle ADB=ADC +BDC=44°, the angle BAD=CAD—BAC=102° 44′, and the side AB=12, to find BD=16.85 miles.

EXAMPLE 6, Fig. 59.

A person having a triangular field, the sides of which measure AB=50 perches, AC=46 perches, and BC=40 perches, wishes to have a well dug in it, that shall be equally distant from the corners A, B, and C. What must be its distance from each corner, and by what angle from the corner A, may its place be found?

Construction.

With the given sides construct the triangle ABC, and (by Prob. 10.) describe a circle that shall pass through the points A, B, and C; then the centre E of this circle is the required place of the well.*

Calculation.

1. In the triangle ABC, all the sides are given, to find the angle ABC=60° 16′.

2. Join CE and produce it to meet the circumference in D; also join AE and AD; then the angles ADC, ABC

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* The demonstration of this is plain (1.3 cor.)

being angles in the same segment, are equal; also the angle DAC being an angle in a semicircle, is a right angle: therefore in the right-angled triangle DAC, we have the angle ADC=ABC=60° 16′, and the side AC, to find CD=52.98 perches. The half of CD is=26.49 perches =CE=the distance of the well from each corner.

3. The angle ACD=90°—ADC=29° 44′; but because AEC is an isosceles triangle, the angle CAE=ACE=29° 44′ the angle required.

EXAMPLE.7, Fig. 61.

Wishing to know the height of a steeple situated on a horizontal plane, I measured 100 feet in a right line from its base, and then took the angle of elevation* of the top, which I found to be 47° 30′ the centre of the quadrant being 5 feet above the ground: required the height of the steeple.

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* Angles of elevation, or of depression, are usually taken with an instrument called a quadrant, the arc of which is divided into 90 equal parts or degrees, and those, when the instrument is sufficiently large may be subdivided into halves, quarters, &c. From the centre a plummet is suspended by a fine silk thread. Fig. 60, is a representation of this instrument.

To take an angle of elevation, hold the quadrant in a vertical position, and the degrees being numbered from B towards C, with the eye at C, look along the side CA, moving the quadrant till the top of the object is seen in a range with this side; then the angle BAD made by the plummet with the side BA, will be the angle of elevation required.

Angles of depression are taken in the same manner, except that then the eye is applied to the centre of the quadrant.

Note.—In finding the height of an object, it is best to take such a position that the observed angle of altitude may be about 45°; for when the observed angle is 45°, a small error committed in taking it, makes the least error in the computed height of the object.

Calculation.

In the right angled triangle DEC, we have the angle CDE=47° 30′, and the base DE=AB=100 feet to find CE=109.13 feet; to CE add EB=DA=5 feet, the height of the quadrant, and it will give BC=114.13 feet, the required height of the steeple.

EXAMPLE 8, Fig. 62.

Wishing to know the height of a tree situated in a bog, at a station D, which appeared to be on a level with the bottom of the tree, I took the angle of elevation BDC=51° 30′; I then measured DA=75 feet in a direct line from the tree, and at A, took the angle of elevation BAC=26° 30′. Required the height of the tree.

Calculation.

1. Because the exterior angle of a triangle is equal to the sum of the two interior and opposite ones, the angle BDC=DAC+ACD; therefore ACD=BDC−DAC=25°: now in the triangle ADC we have DAC=26° 30′, ACD =25°, and AD=75, to find DC=79.18.

2. In the right angled triangle DBC are given DC= 79.18, and the-angle BDC=51° 30′ to find BC=61.97 feet, the required height of the tree.

EXAMPLE 9, Fig. 63.

Wanting to know the height of a tower EC, which stood upon a hill, at A, I took the angle of elevation CAB=44°; I then measured AD 134 yards, on level ground in a straight line towards the tower; at D the angle CDB was 67° 50′ and EDB 51°. Required the height of the tower and also of the hill.

Calculation.

1. In the triangle ADC we have the angle DAC=44°, the angle ACD=BDC—DAC=23° 50′, and the side AD, to find DC=230.4.

2. In the triangle DEC all the angles are given, viz. CDE=B[illegible]C—BDE=16° 50′, DCE=90°—BDC=22° 10′, DEC=180°—the sum of the angles CDE and DCE,= 141°, and CD=230.4, to find CE=106 yards, the height of the tower.

3. In the right-angled triangle DBC, we have the angle BDC=67° 50′, and the side DC=230.4, to find BC= 213.4; then BE=BC—CE=213.4—106=107.4 yards, the height of the hill.

EXAMPLE 10, Fig. 64.

An obelisk AD standing on the top of a declivity, I measured from its bottom a distance AB=40 feet, and then took the angle ABD=41°; going on in the same direction 60 feet farther to C, I took the angle ACD=23° 45′: what was the height of the obelisk?

Calculation.

1. In the triangle BCD, we have given the angle BCD, =23° 45′, the angle BDC=ABD—BCD=17° 15′, and side BC=60, to find BD=81.49.

2. In the triangle ABD are given the side AB=40, BD=81.49, and the angle ABD=41°, to find AD=57.64 feet, the height of the obelisk.

EXAMPLE 11, Fig. 65.

Wanting to know the height of an object on the other side of a river, but which appeared to be on a level with the place where I stood, close by the side of the river; and not having room to go backward on the same plane, on account of the immediate rise of the bank, I placed a mark where I stood, and [illegible]asured in a direct line from the object, up the hill, whose ascent was so regular that I might account it a right line, to the distance of 132 yards, where I perceived that I was above the level of the top of the object; I there took the angle of depression of the mark by the river's side equal 42°, of the bottom of the object equal 27°, and of its top equal 19°: required the height of the object.

Calculation.

1. In the triangle ACD, are given the angle $CAD = EDA = 27°$, $ACD = 180° - CDE\ (FCD) = 138°$ and the side $CD = 132$, to find $AD = 194.55$ yards.

2. In the triangle ABD, we have given $ADB = ADE - BDE = 8°$, $ABD = BED + BDE = 109°$ and $AD = 194.55$, to find $AB = 28.64$ yards, the required height of the object.

EXAMPLE 12, Fig. 66.

A May-pole whose height was 100 feet standing on a horizontal plane, was broken by a blast of wind, and the extremity of the top part struck the ground at the distance of 34 feet from the bottom of the pole: required the length of each part.

Construction.

Draw AB=34, and perpendicular to it, make BC=100; join AC and bisect it in D, and draw DE perpendicular to AC, meeting BC in E; then AE=CE= the part broken off.*

Calculation.

1. In the right-angled triangle ABC, we have AB=34 and BC=100, to find the angle C=18° 47′.

2. In the right-angled triangle ABE, we have AEB=ACE+CAE=2ACE=37° 34′, and AB=34, to find AE =55.77 feet, one of the parts; and 100−55.77=44.23 feet the other part.

PRACTICAL QUESTIONS.

1. At 85 feet distance from the bottom of a tower, the angle of its elevation was found to be 52° 30′: required the altitude of the tower. *Ans.* 110.8 feet.

2. To find the distance of an inaccessible object, I measured a line of 73 yards, and at each end of it took

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* Demonstration. In the triangles AED, DEC, the angle ADE=CDE, the side AD=CD, and DE is common to the two triangles, therefore (4.1) AE=CE.

Note.—This question may be neatly solved in the following manner without finding either of the angles. Thus, draw DF perpendicular to BC, then (31.3 and cor. 8.6) FC : DC :: DC : CE; consequently $CE=\frac{DC^2}{FC}$; but $DC^2=\frac{AC^2}{4}=\frac{AB^2+BC^2}{4}$, and $FC=\frac{1}{2}BC$; therefore $CE=\frac{AB^2+BC^2}{2BC}=\frac{34^2+100^2}{200}=\frac{1156+10000}{200}=\frac{11156}{200}=55.78$, the same as before nearly.

the angle of position of the object and the other end, and found the one to be 90°, and the other 61° 45′: required the distance of the object from each station. *Ans.* 135.9, yards from one, and 154.2 from the other.

3. Wishing to know the distance between two trees C and D, standing in a bog, I measured a base line AB=339 feet; at A the angle BAD was 100° and BAC 36° 30′; at B the angle ABC was 121° and ABD 49°: required the distance between the trees. *Ans.* 697½ feet.

4. Observing three steeples, A, B and C, in a town at a distance, whose distances asunder are known to be as follows, viz. AB=213, AC=404, and BC=262 yards, I took their angles of position from the place D where I stood, which was nearest the steeple B, and found the angle ADB=13° 30′; and the angle BDC=29° 50′. Required my distance from each of the three steeples. *Ans.* AD=571 yards, BD=389 yards, and CD=514 yards.

5. A May-pole, whose top was broken off by a blast of wind, struck the ground at 15 feet distance from the foot of the pole: what was the height of the whole May-pole, supposing the length of the broken piece to be 39 feet? *Ans.* 75 feet.

6. At a certain place the angle of elevation of an inaccessible tower was 26° 30′; but measuring 75 feet in a direct line towards it, the angle was then found to be 51° 30′: required the height of the tower and its distance from the last station. *Ans.* Height 62 feet, distance 49.

7. From the top of a tower by the sea side, of 143 feet high, I observed that the angle of depression of a ship's

bottom, then at anchor, was 35°; what was its distance from the bottom of the wall? *Ans.* 204.2 feet.

8. There are two columns left standing upright in the ruins of Persepolis; the one is 64 feet above the plane, and the other 50; in a right line between these stands an ancient statue, the head of which is 97 feet from the summit of the higher, and 86 from that of the lower column; and the distance between the lower column and the centre of the statue's base is 76 feet: required the distance between the tops of the columns.

Ans. 157 feet.

SURVEYING.

CHAPTER I.

ON THE DIMENSIONS OF A SURVEY.

1. SURVEYING is the art of measuring, laying out and dividing land.

2. *A Four-Pole Chain* is an instrument used for measuring the boundaries of a survey. It is, as its name imports, 4 poles or 66 feet in length, and is divided into 100 equal parts or links. The length of a link is therefore 7.92 inches.

Note.—A Four-pole Chain is frequently called simply a chain.

3. *A Two-pole Chain* is 2 poles or 33 feet in length, and is usually divided into 50 equal parts or links. When it is thus divided, the links are of the same length as in a four-pole chain; and the measures taken with it are reduced to four-pole chains previous to using them in calculation.

Sometimes the two-pole chain is divided into 40 links; in which case, each two links is the one-tenth of a perch. Measures taken with a two-pole chain, thus divided, are usually expressed in perches and tenths.

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4. The *Distance* of a line in surveying, is its length, estimated in a horizontal direction. It is generally expressed either in chains and links, or in perches and tenths.

5. A *Meridian* or *Meridian Line* is any line that runs due north or south.

Note.—All the meridians passing through any survey of moderate extent may be considered as straight lines, parallel to one another.*

6. The *Bearing* or *Course* of a line, is the angle which it makes, with a meridian passing through one end; and it is reckoned from the North or South Points of the horizon towards the East or West Points.

Thus, supposing the line NS, Fig. 77, to be a meridian, and the angle SAB to be 50°; then the bearing of AB from the point A, is 50° to the east of south; which is usually expressed thus: S. 50° E., and read, south, fifty degrees east.

7. The *Reverse Bearing* of a line is the bearing taken from the other end of the line.

Note.—The bearing and the reverse bearing of a line, are angles of the same magnitude,† but lying between directly opposite points. Thus, if the bearing of AB, from the end A, is S. 50° E., the bearing of the same line from the end B, is N. 50° W.

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* The meridians are, in reality, curve lines which meet in the north and south poles of the earth. No two of them are therefore exactly parallel; but in usual surveys their deviation from parallelism is so very small, that there is no sensible error in considering them so.

† As the meridians are not exactly parallel, this is not strictly true, except in a few cases; but the difference is too small to be observed in practice. In

8. A *Circumferentor* or *Surveyor's Compass*, is an instrument used to take the bearings of lines.

The circumference of its face is divided into degrees, and in some of the larger ones into half degrees, in such manner that two opposite points may be exactly in the direction of the sights with which the instrument is furnished. These points are the north and south points of the instrument. Midway between them, on the circumference, are the east and west points. The degrees are numbered from 0° to 90°, each way from the north and south points to the east and west ones. In the centre of the face is a pin, finely pointed, which supports a Magnetic Needle, moving freely within the instrument. The instrument, when used, is placed on a staff, having a pointed iron at the bottom, and a ball and socket at the top.

The Chain and Compass are the instruments with which the dimensions of surveys in this country are generally taken. It is important to have them accurately made. In the selection of a compass, particular attention should be directed to the settling of the needle. If, when the needle has been moved out of its natural position, it settles very soon, it is defective; either its magnetic virtue is weak, or it does not move with sufficient freedom on the pin.

9. The *Difference of Latitude*, or the *Northing* or

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the latitude of Philadelphia the greatest difference between the bearing and reverse bearing of a line, a mile in length, is only 44″. In higher latitudes the difference is greater.

Southing of a line, is the distance that one end is further north or south than the other end; or it is the distance which is intercepted on a meridian passing through one end, between this end and a perpendicular to the meridian, from the other end.

Thus, if NS, Fig. 77, be a meridian passing through the end A, of the line AB, and B*b* be perpendicular to NS, then is A*b* the difference of latitude or southing of AB.

10. The *Departure* or the *Easting* or *Westing* of a line is the distance that one end is further east or west than the other end; or it is the distance from one end, perpendicular to a meridian passing through the other end.

Thus B*b*, Fig. 77, is the departure or easting of the line AB.

But if *ns* be a meridian, and AC perpendicular to it, and if the bearing of the line be taken from B to A, then is BC the difference of latitude or northing, and AC the departure or westing, of the line AB.

Note.—It is evident from the definitions, that the Distance, Difference of Latitude, and the Departure form the sides of a right-angled triangle; in which, considering the departure as the base, the perpendicular is the difference of latitude, the hypothenuse is the distance, and the angle at the perpendicular is the bearing.

11. The *Meridian Distance* of any station, is its distance from a meridian passing through the first station of the survey, or any other assumed point.

12. The *Traverse Table*, is a table containing the dif-

ferences of latitude and the departures, computed to different courses and distances.

13. The *Area* or *Content* of a tract of land is the *horizontal* surface included within its boundaries, expressed in known measures, as Acres, Roods, and Perches.

14. In going round a tract of land and returning to the place of beginning, it is evident that the whole northing which has been made, must be equal to the southing, and the easting to the westing; or in other words, that the sum of all the northings must be equal to that of the southings, and the sum of the eastings, to that of the westings.

This principle enables us to judge of the accuracy of a survey, when the bearings and distances of all the sides have been taken. If the sums of the computed northings and southings are equal, and also those of the eastings and westings; or, if, though not exactly equal, they are very nearly so, we may conclude that the survey has been correctly made; as very small differences in these sums may be imputed to little, unavoidable errors in taking the bearings and measuring the distances. But when the sum of the northings differs considerably from that of the southings, or that of the eastings from that of the westings, we must infer that an error has been made, too great to be admitted. In this case a re-survey should be taken.

It is a rule with some of our best practical surveyors, that when the difference between the sums of the northings and southings, called the *error in latitude*, or that between the sums of the eastings and westings, called the *error in departure*, exceeds one link for every five chains in the sum of the distances, a re-survey ought to be made.

When the errors in latitude and departure fall within the limits just mentioned, they should be properly apportioned among the several latitudes* and departures; we shall thus obtain what are called the corrected latitudes and departures. The method of doing this will be given in one of the following problems.

PROBLEM I.

To reduce two-pole chains and links to four-pole chains and links.

RULE.

1. If the number of chains is *even*, divide it by 2, and to the quotient annex the given number of links.

2. If the number of chains is *odd*, divide by 2 as before, for the chains; and for the 1 that is off, add 50 to the given number of links.

EXAMPLES.

1. In 16 two-pole chains and 37 links, how many four-pole chains and links? *Ans.* 8 *ch.* 37 *links*, or 8.37 *ch.*

2. How many four-pole chains and links are there in 17 two-pole chains and 42 links? *Ans.* 8.92 *ch.*

3. How many four-pole chains and links are there in 22 two-pole chains and 7 links? *Ans.* 11.07 *ch.*

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* In order to conciseness of expression, difference of latitude is frequently called simply, latitude.

PROBLEM II.

To reduce two-pole chains and links to perches and hundredths of a perch.

RULE.

Multiply the links by 4, for the hundredths, and the chains by 2, for the perches. If the hundredths exceed 100, set down the excess, and add 1 to the perches.

Note.—This rule supposes the two-pole chain to be divided into 50 links.

EXAMPLES.

1. Reduce 17 two-pole chains and 21 links to perches and hundredths. *Ans.* 34.84 *per.*

2. Reduce 15 two-pole chains and 38 links to perches and hundredths. *Ans.* 31.52 *per.*

3. Reduce 57 two-pole chains and 49 links to perches and hundredths. *Ans.* 115.96 *per.*

PROBLEM III.

To reduce square four-pole chains to acres.

RULE.

Divide by 10, and the quotient will be the acres. If there is a decimal in the quotient, multiply it by 4, for the roods; and the decimal of these by 40, for the perches.

EXAMPLES.

1. Reduce 523.2791 square chains to acres.

10)523.2791
52.32791
4
1.31164
40
12.46560 *Ans.* 52 *ac.* 1 *r.* 12 *p.*

2. Reduce 41.9682 square chains to acres.
Ans. 4 *ac.* 0 *r.* 31 *p.*

3. Reduce 132.925 square chains to acres.
Ans. 13 *ac.* 1 *r.* 6.8 *p.*

PROBLEM IV.

To reduce acres, roods and perches to square chains.

RULE.

Divide the perches by 40 and prefix the roods; divide the result by 4 and prefix the acres; then this latter result, multiplied by 10, will give the square chains.

Or reduce the given quantity to perches and divide by 16.

EXAMPLES.

1. Reduce 13 *ac.* 1 *r.* 10 *p.* to square chains.

40)10
4)1.25
13.3125 $A=133.125$ *sq. ch.*

2. Reduce 127 *ac.* 3*r.* 23*p.* to square chains.
Ans. 1278.9375 *sq. ch.*

3. Reduce 35 *ac.* 0 *r.* 20 *p.* to square chains.
Ans. 351.25 *sq. ch*

PROBLEM V.

To find the bearing of a line.

1. Let a stake of six or eight feet in length be set up perpendicularly, at the far end of the line. Set up the compass staff perpendicularly, at the beginning of the line, and placing the compass on the staff, adjust it to a horizontal position; the ball and socket admitting a motion for that purpose. This position can be determined with sufficient accuracy, by observing whether, when the compass is turned round, the ends of the needle remain at the same height above the face of the instrument.

2. Turn the compass round so as to bring the south end of it towards the stake at the far end of the line. Then applying the eye to the sight at the north end, move the compass gently round till the stake can be seen through the fine slits in both sights, and let it remain in this position.

3. When the needle has settled, observe the number of degrees and parts of a degree, that are intercepted between the south end of the needle and the north or south point of the compass, to whichever it is nearest; which will be the bearing, reckoning it from *that* point, towards the east if the south end of the needle is to the right hand, but towards the west if it is to the left hand.

Note 1.—The bearing thus obtained may be, and should be, verified by going to the far end of the line, and from thence taking the bearing to the first end, which, if both bearings are correct will be the reverse of the former.

Note 2.—When there is a fence on the side, or other obstacle in the way, preventing the stake at one end from being seen through the compass sights at the other end, the bearing may be obtained by setting up the compass and stake at small *equal* distances to the right or left, so that the line joining them may be parallel to the side.

Note 3.—The method of obtaining the bearing between two stations when there are obstacles in the way, which also prevent a parallel bearing being readily taken, or when the stations are too distant to be seen from each other, will be noticed in the next chapter.

PROBLEM VI.

To measure the distance of a line.

For convenience in marking the termination of the chain in measuring, *ten* iron pins should be provided, about a foot in length, and terminated at top by a small ring, to which a piece of red flannel or other conspicuous substance should be tied, in order that the pins may be readily found, when set up among high grass or in other situations where they would not otherwise be easily discovered.

Let the person who is to go foremost in carrying the chain, take nine of the pins in his left hand, and one end of the chain and the other pin in his right hand; then he moving on in the direction of the line, let another person take the other end of the chain and hold it at the beginning of the line. When the leader has moved on till the chain is stretched tight, he must set down the pin, perpendicularly, exactly at the end of the chain, the hinder chain-man taking care that the chain is in the direction of the line; which is readily determined by observing whether it is in a range with a stake previously set up at the far end of the line. When the leader has not his end of the chain in the direction of the line, the hinder chain-man can direct him which way to move, by a motion of his left hand. When the distance of one chain or half chain* has been thus determined, the carriers, taking hold of the two ends of the chain, move on till the hinder one comes to the pin which was set up by the other; then the chain being stretched, the person at the fore end of it sets up another pin as before; the hinder chain-man then taking up the pin at his end, they proceed to a third distance of the chain; and so on. When the person at the fore end of the chain has set up all his pins, he still moves on another length of the chain, and then setting his foot on it to keep it in place, he cries "*out*." The hinder chain man then comes forward, and counts to him the ten pins; and he setting up one of them at the end of the chain, again moves on, dragging the chain after him, till he is checked by the hinder chain-man, who, getting the hind end of the chain, applies it as before to the pin set up. The number of outs should be carefully noticed; each *out* being ten chains, when a four-pole chain is used, but only five, when the measuring is done, with a two-pole chain. When arrived at the end of the line, the number of pins, which the one at the fore end of the chain has set up since the last *out*, and the number of links from the last pin to the end of the line, must be carefully noted. From these, and the number of *outs*, the distance measured is readily determined.

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* When a two-pole chain is used, one length of it may properly be called a half chain.

All slant or inclined surfaces, as the sides of a hill, should be measured horizontally, and not on the plane or surface of the hill. To effect this, the hind end of the chain, in ascending a hill, should be raised from the ground till it is on a level with the fore end, and, by means of a plummet and line, or when the hill is not very steep. by estimation, should be held perpendicularly above the termination of the preceding chain. In descending a hill, the fore end of the chain should be raised in the same manner, and the plummet being suspended from it will show the commencement of the succeeding chain.

PROBLEM VII.

To protract a Survey, having the bearings and distances of the sides given.

The method of doing this will be best understood by an example. Thus,

Suppose the following field-notes to be given, it is required to protract the survey.

		Ch.
1.	N. 50° E.	9.60
2.	S. 32° E.	16.38
3.	S. 41° W.	6.30
4.	West	8.43
5.	N. 79° W.	10.92
6.	N. 5° E.	11.25
7.	S. 83° E.	6.48

Method 1st.

Draw NS, Fig. 75, to represent a meridian line; then N standing for the north and S for the south, the east will be to the right hand and the west to the left. In

NS take any convenient point as A for the place of beginning, and apply the straight edge of the protractor to the line, with the centre to the point A, and the arch turned towards the east, because the first bearing is easterly; then holding the protractor in this position, prick off 50° the first bearing, from the north end, because the bearing is from the north; through this point and the point A, draw the line AB on which lay 9.60 chains, the first distance from A to B. Now apply the centre of the protractor to the point B, with the arch turned toward the east, because the second bearing is easterly, and move it till the line AB produced, cuts the first bearing 50°; the straight edge of the protractor will then be parallel to the meridian NS; hold it in this position, and from the south end prick off the second bearing 32°; draw BC and on it lay the second distance 16.38 chains. Proceed in the same manner at each station, observing always, previous to pricking off the succeeding bearing, to have the arch of the protractor turned easterly or westerly according to that bearing, and to have its straight edge parallel to the meridian; this last may always be done by applying the centre to the station point, and making the preceding distance line produced if necessary, cut the degrees of the preceding bearing. It may also be done by drawing a straight line through each station, parallel to the first meridian.

When the survey is correct, and the protraction accurately performed, the end of the last distance will fall on the place of beginning.

Method 2nd.

With the chord of 60° describe the circle NESW, Fig. 76, and draw the diameter NS. Take the several bearings from the line of chords, and lay them off on the circumference from N or S according as the bearing is northerly or southerly, and towards E or W according as it is easterly or westerly, and number them 1, 2, 3, 4, &c. as in the figure. From A the centre of the circle, to 1 draw A 1, on which lay the first distance from A to B; parallel to A 2 draw BC, on which lay the second distance from B to C: parallel to A 3 draw CD, on which lay the third distance from C to D; proceed in the same manner with the other bearings and distances.

EXAMPLE 2.

The following field notes are given, to protract the survey.

		Ch.
1.	N. 15° 00′ E.	20
2.	N. 37° 30′ E.	10
3.	East	7.50
4.	S. 11° 00′ E.	12.50
5.	South	13.50
6.	West	10.
7.	S. 36° 30′ W.	10.
8.	N. 38° 15′ W.	8.50

PROBLEM VIII.

The bearing of two lines from the same station being given, to find the angle contained between them.

RULE.

When they run from the *same* point of the compass, towards the *same* point, *subtract* the less from the greater.

When they run from the *same* point, towards *different* points, *add* them together.

When they run from *different* points, towards the *same* point, *add* them together, and take the *supplement* of the sum.

When they run from *different* points, towards *different* points, *subtract* the less from the greater, and take the *supplement* of the remainder.

Note.—When the bearing of one of the lines is given *towards* the station, instead of from it, take the reverse bearing of such line; the angle may then be found by the above rule.

EXAMPLES.

1. Given the bearing of the line AB, Fig. 67, N. 34° E., and AD, N. 58° E.; required the angle A.

AD, N. 58° E.
AB, N. 34° E.

Angle A=24°

2. Given the bearing of BA, Fig. 57, S. 34° W., and BC, S. 35° E.; required the angle B. *Ans.* B=69°

3. Given the bearing of BC, Fig. 67, S. 35° E., and CD, S. 87° W.; required the angle C. *Ans.* 58°.

4. Given the bearing of DC, Fig. 67, N. 87° E., and DA, S. 58° W.; required the angle D. *Ans.* 151°.

PROBLEM IX.

To change the bearings of the sides of a survey in a corresponding manner, so that any particular one of them may become a Meridian.

RULE.

Subtract the bearing of the side that is to be made a meridian, from those bearings that are between the *same* points that it is, and also from those that are between points directly *opposite* to them. If it is *greater* than either of the bearings from which it is to be subtracted, take the difference, and change E. to W., or W. to E.

Add the bearing of the side which is to be made a meridian, to those bearings which are neither between the same points that it is, nor between the points that are directly opposite to them. If either of the sums exceeds 90°, take the *supplement* and change N. to S., or S. to N.*

Note.—When the bearings of some, or all, of the sides of a survey have been thus changed, and by calculation the changed bearing of another side or line has been found, its *true* bearing will be obtained by applying to the changed bearing, the bearing of the side which was made a meridian, in a contrary manner to what is directed in the rule; that is, by adding in the case in which the rule directs to subtract, and by subtracting in the case in which it directs to add.

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* The changing of the bearings so as to make a given side become a meridian, may be illustrated by means of a protracted survey. If a protracted survey or plot is held horizontally, with the meridian in a north and south direction, the north end being towards the north, the bearings of the sides of the plot will then correspond with the bearings of the sides of the survey. If then, keeping the paper horizontal, it be turned round till any particular side of the plot has a north and south direction, or becomes a meridian, the bearings of all the other sides of the plot will have been changed by a like quantity. But it is evident, that neither the relation of the different parts of the plot to one another, the area nor the lengths of the sides will have been altered by this change. It may be here observed, that some calculations in surveying are considerably shortened by changing the bearings so as to make a certain side become a meridian. The method was communicated to me by *Robert Patterson, late Professor of Mathematics and Natural Philosophy in the University of Pennsylvania.*

EXAMPLES.

1. Given the bearings of the sides of a survey as follow; 1st. S. 45½° W.; 2d. N. 50° W., 3d. North; 4th. N. 85° E.; 5th. S. 47° E.; 6th. S. 20½° W.; and 7th. N. 51¼° W. Required the changed bearings, so that the 5th side may be a meridian.

1st. S. 45½° W.
47
92½
180
chang. bear. N. 87½° W

2d. N. 50° W.
47
chang. bear. N. 3° W.

3d N. 0° E.
47
hang. bear. N. 47 E.

4th. N. 85° E.
47
132
180
chang. bear. S. 48 E.
N

5th. side, changed bearing, South.

6th. S. 20½° W.
47

chang. bear. S. 67½

7th. N. 51° W.
47

chang bear. N. 4¼ W.

2. Given the following bearings of the sides of a survey; 1st. S. 40½° E.; 2d. N. 54° E.; 3d. N. 29¼° E.; 4th. N. 28¾° E.; 5th. N. 57° W.; and 6th. S. 47° W.; to find the changed bearings so that the 2d. side may be a meridian. *Ans.* 1st. N. 85½° E.; 2d. North; 3d. N. 24¾° W., 4th. N. 25¼° W.; 5th. S. 69° W.; 6th. S. 7° E.

3. Given the bearings as in the 1st. example; viz. 1st. S. 45½° W.; 2d. N. 50° W.; 3d. North; 4th. N. 85° E.; 5th. S. 47° E.; 6th. S. 20½° W; 7th. N. 51¼° W.; to find the changed bearings so that the 6th side may be a meridian. *Ans.* 1st. S. 25° W.; 2d. N. 70½° W.; 3d. N. 20½° W.; 4th N. 64½° E.; 5th. S. 67½° E.; 6th. South; 7th. N. 71¾° W.

PROBLEM X.

Of the bearing, Distance, Difference of Latitude and Departure, any two being given, to find the other two.

RULE.

When the bearing and distance are given.

As Rad. : cos. of bearing : : distance : dif. of latitude.
Rad. : sin. of bearing : : distance : departure.

When the bearing and difference of latitude are given.

As Rad. : sec. of bearing : : diff. lat. : distance.
Rad. : tang. of bearing : : diff. lat. : departure.

When the bearing and departure are given.

As Rad. : cosec. of bearing : : departure : distance.
Rad. : cotang. of bearing : : departure : diff. lat.

When the difference of latitude and the departure are given.

As diff. lat. : departure : : rad. : tang. of bearing.
Rad. : sec. of bearing : : diff. lat. : distance.

When the distance and difference of latitude are given.

As Diff. lat. : distance : : rad. : sec. of bearing.
Rad. : tang. of bearing : : diff. lat. : departure.

When the distance and departure are given.

As Distance : departure : : rad. : sin. of bearing.
Rad. : cos. of bearing : : distance : diff. lat.

Note.—It is evident the above proportions are the solutions of a right-angled triangle, having for its sides the distance, difference of latitude, and departure.

EXAMPLES.

1. Given the bearing of a line, N. 53° 20′ E., distance 13.25 ch.; to find the difference of latitude and the departure. *Ans.* Diff. lat. 7.91 N.: dep. 10.63 E.

2. Given the bearing of a line, S. 32° 30′ E., and the departure 10.96 ch. to find the distance and difference of latitude. *Ans.* Dist. 20.40 ch.; diff. lat. 17.20 S.

3. Given the distance of a line, running between the north and east, 44 ch. and its difference of latitude 34.43 ch.; to find the bearing and departure.

Ans. Bearing, N. 38° 30′ E.; dep. 27.39 ch. E.

4. The bearing of a line S. 32° 30′ E., and the difference of latitude 17.21 ch. being given, to find the distance and departure. *Ans.* Dist. 20.41 ch.; dep. 10.96 E.

5. Given the difference of latitude of a line 27.92 N., and the departure 5.32 E.; to find the bearing and distance. *Ans.* Bearing, N. 10° 47′ E.; dist. 28.42.

6. The distance of a line, running between the north and west, is 35.35 ch., and its departure 15.08 ch., required the bearing and difference of latitude.

Ans. Bearing N. 25° 15′ W.; diff. lat. 31.97 N.

PROBLEM XI.

To find the difference of latitude and departure corresponding to any given bearing and distance, by means of the Traverse Table.

RULE.

When the distance is any number of whole chains or perches, not exceeding 100.

Find the given bearing at the *top* or *bottom* of the table, according as it is *less* or *more* than 45°. Then against the given distance, found in the column of distances at the side of the table, and under or over the given bearing, is the difference of latitude and departure; which must be taken as marked at the top of the table, when the bearing is at the top; but as marked at the bottom, when the bearing is at the bottom.

When the distance is a number of whole chains or perches, exceeding 100.

Separate the distance into parts that shall not exceed 100 each; and find, as before, the difference of latitude and departure, corresponding to the given bearing and to each of those parts; the sums of these will be the difference of latitude and departure required.

When the distance is expressed by chains or perches and the decimal of a chain or perch.

Find, as above, the difference of latitude and departure corresponding to the given bearing and to the whole chain or perches. Then considering the decimal part as a whole number, find the difference of latitude and departure corresponding to it, and remove the decimal point in each of them, two figures to the left hand if there are two decimal figures in the distance, or one figure to the left if there is but one; then these added to the former will give the difference of latitude and departure required.

Note. When the number of whole chains or perches is less than 10, and the second decimal figure is a cipher, the difference of latitude and departure may be taken at once, by considering the mixed number, rejecting the cipher, as a whole number. The difference of latitude and departure thus found, must have the decimal point in each, removed one figure to the left hand.

EXAMPLES.

1. Given the bearing of a line S. 35¼° E., di[illegible]79 ch.; required the difference of latitude and departure by the traverse table. *Ans.* Diff. lat. 64.51 S.; dep. 45.59 E.

2. A line bears N. 20½° E., 117 ch.; required the difference of latitude and the departure.

Dist. 100, gives	diff. lat. 93.67	and dep. 35.02
17 ——	15.92	5.95
Whole dist. 117	diff. lat. 109.59 N.	dep. 40.97 E.

3. Required the difference of latitude and the departure of a line which bears, S. 41¾° W., 57.36 ch.

Dist. 57.00 gives	diff. lat. 42.53	and dep. 37.96
36 ——	.27	.24
Whole dist. 57.36	diff. lat. 42.80 S.	dep. 38.20 W.

4. Required the difference of latitude and departure of a line which bears, N. 72° W., 124.37 ch.

Dist. 100.0 gives	diff. lat. 30.90	and dep. 95.11
24.00——	7.42	22.83
.37——	.11	.35
Whole dist. 124.37	diff. lat. 38.43 N.	dep. 118.29 W.

5. Given the bearing and distance of a line, N. 39½° W. 15.20 ch., to find its difference of latitude and departure. *Ans.* Diff. lat. 11.72 N., and dep. 9.67 W.

6. The bearing and distance of a line are N. 46° E., 27.25 ch.; required its difference of latitude and departure. *Ans.* Diff. lat. 18.93 N. and dep. 19.60 E.

7. The bearing and distance of a line are S. 37¼° W., 137.50 ch.; required its difference of latitude and departure. *Ans.* Diff. lat. 109.45 S., and dep. 83.23 W.

8. Required the difference of latitude and departure of a line, whose bearing and distance are S. 6½° E., 5.60 ch. *Ans.* Diff. lat. 5.56 S., and dep. 0.63 E.

PROBLEM XII.

Given the bearings and distances of all the sides of a tract of land to obtain the corrected latitudes and departures.

RULE.

1. Rule a table as in the annexed example, in the first vertical column of which, place the letters designating the sides, or the numbers denoting the stations at the beginning of each side; in the second column, place the bearings; and, in the third, the distances.

2. Find, by the last problem, the difference of latitude and the departure, corresponding to each side, and place them in the next four columns, under their proper heads of N. or S., E. or W. Add up the northings and southings; and if the sums are not equal, find their difference;

which will be the error of the survey in difference of latitude; which call by the same name as the *least* sum. Proceed in the same manner with the eastings and westings, and find the error in departure. Also add up the column of distances. Then it will be,

As the sum of the distances,
Is to any particular distance,
So is the *error* in latitude or departure
To the *correction* of latitude or departure, corresponding to that distance.

3. Find, by the above proportion, the corrections of latitude and departure corresponding to all the sides, calculating them to the nearest two decimal figures, and place them in the next two columns, heading them with the *same names* as the *errors* in latitude and departure. If the sums of these corrections, are not respectively equal to the errors in latitude and departure, which, in consequence of the fractions neglected, will sometimes be the case, alter some of them by a unit in the second decimal figure, to make them so.

4. Apply these corrections to their corresponding differences of latitude and departures, by *adding* when of the *same* name, but by *subtracting* when of *different* names, and the corrected differences of latitude and departures will be obtained; which may be placed in the four succeeding columns.

In these the sums of the northings and southings will be equal, and also those of the eastings and westings.*

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* The directions given in the rule, for correcting the errors in difference of latitude and departure, are deduced from the rule given and demonstrated in No. 4, of a periodical work, called the Analyst, by *Nathaniel Bowditch*, A. M., and also by the editor, *Professor Adrain*. The demonstration is too long, and not of a nature for insertion here.

Note 1.—In the proportion for finding the correction of the latitude or departure, the decimal parts of the sum of the distances and of the particular distance may be omitted, taking, in each case, the nearest number of whole chains.

2. The corrections may be frequently estimated with sufficient accuracy without the trouble of working out the proportions.

3. When one or two of the sides are hilly, or when there are other difficulties in the way of obtaining their bearing or distances with accuracy, it is better to allow a considerable part of the errors, on the latitudes and departures corresponding to them, and afterwards to apportion the remaining part among the others.

EXAMPLES.

1. Given the bearings and distances of the sides of a tract of land as follow: 1st. S. 40½° E. 31.80 ch.; 2nd. N. 54° E. 2.08 ch.; 3rd. N. 29¼° E. 2.21 ch.; 4th. N. 28¾° E. 35.35 ch.; 5th. N. 57° W. 21.10 ch.; 6th. S. 47° W. 31.30 ch. Required the corrected differences of latitude and departures.

Sta.	Courses.	Dist. Ch.	N. L.	S. L.	E. D.	W. D.	Cor. S.	Cor. E.	N. L.	S. L.	E. D.	W.D.
1	S. 40½ E.	31.80		24.18	20.65		.03	.05		24.21	20.70	
2	N. 54 E.	2.08	1. 23		1.68		.00	.00	1.23		1.68	
3	N. 29¼ E.	2.21	1.92		1.08		.00	.00	1.92		1.08	
4	N. 28¾ E.	35.35	31.00		17.00		.04	.05	30.96		17.05	
5	N. 57 W.	21.10	11.49			17.69	.02	.03	11.47			17.66
6	S. 47. W.	31.30		21.34		22.89	.03	.04		21.37		22.85
		123.84	45.64	45.52	40.41	40.58	.12	.17	45.58	45.58	40.51	40.51
			45.52			40.41						
			12 Er. S.			.17 Er. E.						

As 124 : 32 :: .12 : .03
124 : 2 :: .12 : .00
24 : 35 :: .12 : .03 or .04
124 : 21 :: .12 : .02
124 : 31 :: .12 : .03

As 124 : 32 :: .17 : .04 or .05*
124 : 2 :: .17 : .00
124 : 35 :: .17 : .05
124 : 21 :: .17 : .03
124 : 31 :: .17 : .04

2. Given the bearings and distances of the sides of a tract of land as follow: 1st. N. 75° E. 13.70 ch.; 2d. N. 20¼ E. 10.30 ch.; 3d. East 16.20 ch.; 4th. S. 33¼° W. 35.30 ch.; 5th. S. 76 W. 16 ch.; 6th. North 9 ch.; 7th. S. 84° W. 11.60 ch.; 8th. N. 53¼° W. 11.60 ch.; 9th. N. 36¾° E. 19.36 ch.; 10th. N. 22½° E. 14 ch.; 11th. S. 76¾° E. 12 ch.; 12th. S. 15° W. 10.85 ch.; 13th. S. 18° W. 10.62 ch.; to the place of beginning. Required the corrected latitudes and departures.

Ans. 1st. 3.56 N. 13.26 E.; 2d. 9.66 N. 3.62 E.; 3d. 0.02 N. 16.22 E.; 4th. 29.39 S. 19.44 W.; 5th. 3.85 S. 15.50 W.; 6th. 9.01 N. 0.01 E.; 7th. 1.19 S. 11.52 W.; 8th. 6.96 N. 9.27 W.; 9th. 15.54 N. 11.61 E.; 10th. 12.95 N. 5.38 E.; 11th. 2.73 S. 11.70 E.; 12th. 10.46 S. 2.80 W.; 13th. 10.08 S. 3.27 W.

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* When, as in this case, the correction is found to be nearly midway between two numbers, it is best to note them both. Then, if in using the one that is nearest to the true value, the sum of the corrections does not equal the whole error, the other should be taken.

CHAPTER II.

On supplying omissions in the dimensions of a survey.

When the bearings and distances of all the sides of a survey are known, except one bearing and one distance, or two bearings, or two distances, these can be obtained by calculation, provided those that are known can be depended on, as sufficiently accurate. This may sometimes be necessary when there are obstacles in the way of obtaining one or two of the bearings or distances; or when, after they have all been taken on the ground, the notes of one or two of them happen to be obliterated. As, however a bearing, or distance thus obtained, must be affected by any error or errors that may have been made in taking the others, it is better, when practicable, to have the bearings and distances of all the sides, as taken on the ground.

PROBLEM I.

The bearings and distances of all the sides of a tract of land, except the bearing and distance of one side, being given, to find these.

RULE.

Find by prob. 11, of the preceding chapter, the differences of latitude and the departures for the sides whose bearings and distances are given, and place them in their proper columns in a table ruled for the purpose: Add up the northings and southings, and taking the difference of their sums, place it opposite the unknown side, in the column whose sum is the least. The sums of the two columns will then be equal. This is called *balancing* the latitudes. Do the same with the eastings and westings. The two numbers inserted to make the latitudes and the departures balance, will be the difference of latitude and the departure of the unknown side; with which its bearing and distance may be found, by prob. 10, of the preceding chapter.

Note 1.—By the application of this rule, the bearing and distance of a line joining two corners or stations, may be found, when there are obstacles in the way which prevent our going directly from one corner to the other, or when one cannot be seen from the other. To do this, let one or two, or more stations, if necessary, be taken out of the line, and take the bearing and distance from the first corner to the first assumed station; from this station to the second; and so on, to the second corner. Then considering these bearings and distances, as the bearings and distances of the sides of a survey, the required bearing and distance of the line may be found by the above rule. The bearing thus found must be ***reversed***, in order to have the bearing from the ***first*** corner to the ***second***

2. In the same way the bearing and distance of a ***straight road*** to run between two given places, may be found, by taking the several bearings and distances of the old road if there is one; or of lines joining assumed stations and extending from one of the places to the other.

EXAMPLES.

1. The bearings and distances of the side of a tract of land, except the bearing and distance of one side which

are not known, are as in the following field-notes; required the unknown bearing and distance.

	Chains.
1. S. 45°½ W.	15.16
2. N. 50° W.	22.10
3. North	18.83
4. N. 85° E.	35.65
5. ———	———
6. S. 20½ W°.	23.80
7. N. 51¼ W°.	26.47

Sta.	Bearings.	Dist.	N.	S.	E.	W.
1	S. 45½ W.	15.16		10.62		10.81
2	N. 50 W.	22.10	14.20			16.93
3	North	18.83	18.83			
4	N. 85 E.	35.65	3.11		35.52	
5				(19.79)	(21.20)	
6	S. 20½ W.	23.80		22.29		8.33
7	N. 51¼ W.	26.47	16.56			20.65
			52.70	52.70	56.72	56.72

As diff. of lat. 19.79 S. Ar. Co. 8.70355
: dep. 21.20 E. - - - 1.32674
: : rad. - - - - - - - - - - 10.00000

: tang. bear. S. 47° E. - - - 10.03029

As rad. - - - - - - - - - 10.00000
: sec. bearing 47° - - - - - 10.16622
: : diff. lat. 19.79 - - - - 1.29645

: dist. - - 29.02 - - - - 1.46267

Ans. S. 47° E. 29.02 ch.

2. Given the bearings and distances of the sides of a tract of land, as follow: 1st. N. 15¾ W. 9.40 ch.; 2d N. 63¾ E. 10.43 ch.; 3d. S. 49° E. 8.12 ch.; 4th. S. 13½ E. 8.45 ch.; 5th. S. 16¾ E. 6.44 ch.; 6th. Unknown; 7th. N. 60° W. 9.72 ch.; 8th. N. 17¼ E. 7.65 ch.; required the bearing and distance of the 6th. side.

Ans. S. 60° 8′ W. 12.27 ch.

3. One side of a tract of land of which a survey is to be taken, passes through a pond. Two stations are therefore taken on one side of the pond as represented in Fig. 80. The bearings and distances from the first end of the side to the first station, from that to the second, and thence to the other end of the side are; 1st. S. 52° W. 10.70 ch.; 2d. S. 7½° W. 13.92 ch.; and 3d. S. 34¼ E. 9 ch. Required the bearing and distance of the side. *Ans.* S. 10° 33′ W. 28.31 ch.

4. Given the bearings and distances of an old road, running between two places, as follow; 1st. S. 10° E. 92.20 ch.; 2d. S. 15° W. 120.50 ch.; 3d. S. 18½ W. 205. ch.; 4th. S. 71½ E. 68 ch. Required the bearing and distance of a straight road, that shall connect the two places. *Ans.* S. 2° 8′ W. 423.47 ch.

PROBLEM II.

Given all the bearings and distances of the sides of a survey, except the distances of two sides, to find these.

RULE.

By prob. 9, of the preceding chapter, change all the given bearings, in a corresponding manner, so that one of the sides whose bearings only are given, may become a meridian. With the changed bearings and given distances find the corresponding differences of latitude, and the departures. Add up the eastings and westings, and take the difference of their sums, which will be the departure of that unknown side, which is not made a meridian. With this departure and the changed bearing, find by prob. 10, of the preceding chapter, the distance and difference of latitude of this side, which place in their proper columns. Now add up the northings and southings, and take their difference, which will be the distance of the side made a meridian.*

EXAMPLES.

Given the following bearings and distances of the sides of a survey; 1st. S. 45½ W. 15.16 ch.; 2d. N. 50° W. 22.10 ch.; 3d. North 18.83 ch.; 4th. N. 85° E. 35.65 ch.; 5th. S. 47° E. dist. unknown; 6th. S. 20½ W. dist. unknown; 7th. N. 51¼ W. 26.47 ch. to the place of beginning. Required the unknown distances.

Sta.	Bearings.	Changed bearings.	Dist.	N.	S.	E.	W.
1	S. 45½° W.	N. 87½° W.	15.16	0.66			15.15
2	N. 50 W.	N. 3 W.	22.10	22.07			1.16
3	North	N. 47 E.	18.83	12.85		13.77	
4	N. 85 [illegible]	S. 48 E.	35.65		23.85	26.49	
5	S. 47 E.	South	(29.02)		(29.02)		
6	S. 20½ W.	S. 67½ W.	(23.80)		(9.11)		(21.99)
7	N. 51¼ W.	N. 4¼ W.	26.47	26.40			1.96
				61.98	61.98	40.26	40.26

---

* The reason of the rule is obvious. For as the side made a meridian has no departure, the difference of the sums of the departures, must be the departure of the other unknown side. And when the difference of latitude of this side has been found and placed in its proper situation, the difference of the sums of the latitudes must evidently be the difference of latitude of the side made a meridian; or which, in this case, is the same thing, its distance.

As rad. - - - - - - - -		10.00000
: cosec. chang. bearing	67½° - -	10.03438
: : dep. - - - - - -	21.99	1.34223
: Dist. 6th side - -	23.80 -	1.37661

As rad. - - - - - - - - - -		10.00000
: cotang. chang. bearing	67½ - -	9.61722
: : dep. - - - - - -	21.99 -	1.34223
: diff. lat. 6th. side - -	9.11 -	0.95945

Ans. 5th. side 29.02 ch. and 6th. side 23.80 ch.

2. Given the bearings and distances of a tract of land as follow: 1st. S. 40½ E. 31.80 ch.; 2d. N. 54° E. dist. unknown; 3d. N. 29¼ E. 2.21 ch.; 4th. N. 28¾ E. 35.35 ch.; 5th. N. 57° W. dist. unknown; 6th. S. 47° W. 31.30 ch.; to the place of beginning. Required the distances of the 2d. and 5th. sides.

Ans. 2d. side. 2.08 ch. and 5th. side 20.90 ch.

PROBLEM III.

Given the bearings and distances of all the sides of a survey except two; one of which has only its bearing given, and the other, the distance and the points of the compass between which it runs; to find the unknown bearing and distance.

RULE.

As in the last problem, change all the given bearings, so that the side whose bearing only is given, may become a meridian. Find the differences of latitude and the departures, corresponding to the changed bearings and the given distances. Take the difference of the sums of the eastings and westings, which will be the departure of the side whose bearing is not given. With the given distance and this departure, find by chap. 1. prob. 10. the changed bearing and difference of latitude, and place them in their proper columns. From the changed bearing, the true bearing may be readily found by note to prob. 9. chap. 1. Lastly, take the difference of the sums of the northings and southings, and it will be the distance of the side, changed to a meridian.

Note.—The changed bearing as found by the rule, must be reckoned from the *north*, or the *south* point of the compass, according as the one, or the other, will render the true bearing when found from it, conformable to the given points. The point from which the changed bearing must be reckoned determines also the column in which the difference of latitude must be placed. Sometimes the changed bearing when reckoned from either north or south, will render the true bearing conformable to the given points. In such cases, there are two different bearings and distances that will answer the conditions of the problem; and we can only know which of them is the right one by previously knowing the required bearing nearly.

EXAMPLES.

1. Given the bearings and distances of a survey as follow: 1st. S. *unknown* W. 15.16 ch.; 2d. N. 50° W. 22.10 ch.; 3d. N. 18.83 ch.; 4th. N. 85° E. 35.65 ch.; 5th. S. 47° E. 29.02 ch.; 6th. S. 20½ W. dist. unknown, 7th. N. 51¼° W. 26.47 ch. Required the unknown bearing and distance.

Sta.	Bearings.	Changed bearings.	Dist.	N.	S.	E.	W.
1	S. (45° 36′) W.	(S. 25° 6′ W.)	15.16		13.73		(6.43)
2	N. 50 W.	N. 70½ W.	22.10	7.37			20.83
3	North	N. 20½ W.	18.83	17.64			6.59
4	N. 85 E.	N. 64½ E.	35.65	15.35		32.18	
5	S. 47 E.	S. 67½ E.	29.02		11.11	26.81	
6	S. 20½ W.	South	(23.81)		(23.81)		
7	N. 51¼ W.	N. 71¾ W.	26.47	8.29			25.14
				48.65	48.65	58.99	58.99

As dist. 1st. side 15.16 Ar. Co. 8.81930
: dep. do. 6.43 0.80821
: : rad. - - - - - - - - - - 10.00000

: sin. chan. bear. 25° 6′ - - - 9.62751

As rad. - - - - - - - - - - 10.00000
: cos. chang. bearing 25° 6′ - - 9.95692
: : dist. - - - - - 15.16 - - 1.18070

: diff. lat. - - - - 13.73 - - 1.13762
Ans. 1st. S. 45° 36′ W.; 6th. 23. 81 ch.

2. Given the following bearings and distances of a survey: 1st. S. 40½° E. 31.80 ch.; 2d. N. 54° E. dist. *unknown* 3rd. N. 29¾° E. 2.21 ch.; 4th. N. *unknown* E. 35.35 ch.; 5th. N. 57° W. 20.90 ch.; 6th. S. 47° W. 31.30 ch.; to place of beginning. Required the bearing of the 4th. side and distance of the 2d. side.

Ans. Bearing of 4th. side N. 28¾° E.; dist. of 2d. side, 2.09 ch.

PROBLEM IV.

Given all the bearings and distances of the sides of a tract of land, except the bearings of two sides, to find these bearings.

RULE.

1. Find the difference of latitude and the departure ot each side, whose bearing and distance are both given. Take the difference of the sums of the northings and southings of these sides, and also the difference of the sums of the eastings and westings. These differences will be the difference of latitude, and the departure of a line, which, with those sides, would form a closing survey; and which may therefore be called a *closing line.*

2. With the difference of latitude and departure of the closing line, find, by prob. 10. chap. 1, its bearing and distance. Take the closing line and the two sides whose bearings are not given, for the three sides of a triangle, and calculate the angles.

3. To the bearing of the closing line, apply, by addition or subtraction, as the case may require, the angle contained between it, and the side which is the one coming first in the order of the survey; and it will give the bearing of that side. Then to the reverse bearing of that side, apply in a proper manner, the angle contained between the two sides which are sides of the survey, and it will give the bearing of the second of those sides.[*]

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[*] It is easy to see the reason of the rule, by considering that the two sides whose bearings are not given, being made to form with the closing line, the

EXAMPLES.

1. Given the bearings and distances of the sides of a tract of land as follow: 1st. S. *unknown* W. 15.16 ch.; 2d. N. 50° W. 22.10 ch.; 3d. North 18.83 ch.; 4th. N. 85° E. 35.65 ch.; 5th. S. *unknown* E. 29.02 ch.; 6th S. 20¼° W. 23.80 ch.; and 7th. N. 51¼ W. 26.47. ch. Required the unknown bearings.

Sta.	Bearings.	Dist.	N.	S.	E.	W.
1	S. W.	15.16				
2	N. 50° W.	22.10	14.20			16.93
3	North	18.83	18.83			
4	N. 85 E.	35.65	3.11		35.52	
5	S. E.	29.02				
6	S. 20¼ W.	23.80		22.29		8.33
7	N. 51¼ W.	26.47	16.56			20.65
			52.70	22.29	35.52	45.91
			22.29			35.52
			30.41 S.			10.39 E.

---

sides of a triangle, the sum or difference of their differences of latitude, will necessarily be equal to the difference of latitude of the closing line; and that, therefore, their differences of latitude will be such as to make the sums of the northings and southings of the whole survey equal; and the same for the departures.

As diff. lat.	30.41 S.	Ar. Co. 8.51698
: dep.	10.39 E.	1.01662
:: rad.		10.00000
: tang. of bear. of clos. line, S. 18° 52′		9.53360

As rad.		10.00000
: diff. lat.	30.41	1.48302
:: sec. of bear. of clos. line	18° 52′	10.02398
: dist. of clos. line	32.14	1.50700

Let DE, Fig. 78, represent the closing line, DF, the 1st. side of the survey, and FE, the 5th. side. Then,

DE	32.14	
DF	15.16	Ar. Co. 8.81930
FE	29.02	——— 8.53730
	2)76.32	
Half sum	38.16	log. 1.58161
Remainder	6.02	— 0.77960
Cos. ½ F	43° 44′	2)19.71781
F	87 28	9.85890

As DE	32.14	Ar. Co. 8.49295
: FE	29.02	1.46270
:: sin. F	87° 28′	9.99958
sin. D	64° 26′	9.95523

DE, S. 18° 52′ E.	FD, N. 45° 34′ E.
Angle D 64 26	Angle F 87 28
1st. side, S. 45 34 W.	133 2
	180 00
	5th. side, S. 46 58 E.

2. Given the bearings and distances of the sides of a tract of land as follow: 1st. S. *unknown* E. 31.80 ch.; 2d. N. 54° E. 2.08 ch.; 3d. N. 29¼ E. 2.21 ch. 4th. N. 28¾° E. 35.35 ch.; 5th. N. 57° W. 20.90 ch.; and 6th. S. *unknown* W. 31.30 ch. to the place of beginning. Required the unknown bearings.

Ans. 1st. S. 40° 29′ E.; and 6th. S. 47° W.

CHAPTER III.

Problems for finding the Content of Land.

When the sides of a survey are right lines, and all the bearings and distances are given, the area may be found by a problem that will be given in this chapter. If one or two of the bearings or distances are not known, they may be found by the problems in the last chapter. Although the problem alluded to, is general, and may be applied whatever number of sides there may be, yet there are some particular rules for finding the areas of triangles and quadrilaterals, which are often useful. These, and also rules for finding the areas of circles and ellipses are given in the first part of the chapter.

When a part of the boundary of a tract of land, is irregular, as is frequently the case, if one or more of the sides are bounded by water, it is sometimes very troublesome to take all the bearings and distances requisite to obtain the area with accuracy. In these cases, it is usual to run one or more straight lines, called *stationary* lines, near to such boundary, and so as to connect the straight sides of the survey. In measuring these stationary lines, perpendicular distances are measured from them, to each bend in the irregular boundary. These perpendicular distances are called *off-sets*. The lengths of the off-sets, and the distance of the foot of each, from the commencement of the stationary line, should be carefully noted in the field book; observing also that such a number of off-sets should be taken, that the part of the irregular boundary intercepted between each adjacent two, may, without material error, be considered a straight line.. From these notes, the area or areas of the land contained between the stationary line or lines, and the irregular boundary, may readily be calculated. This area added to the area enclosed by the stationary lines, and straight sides of the survey, when they are on the outside of the stationary lines, or subtracted from it, when on the inside, will give the area of the survey.

In those cases in which water is a boundary of a tract of land, if that water is a brook or rivulet, it is usuul to consider a line running through its *middle* as the true boundary; and the off-sets must be measured accordingly. When tide water is the boundary, the land is considered as extending to the line of *low water mark.*

If the bearings of all the corners of a tract of land from two stations, taken either within or out of the tract are given, and also the bearing and distance of these stations from each other, the area may be calculated. It is however necessary, that the two stations should be so taken that they shall not be in a straight line, or very nearly in a straight line, with either of the corners of the land. This method of obtaining the area, though not practically so accurate as where the bearings and distances of the sides are correctly given, may sometimes be found useful.

Some surveyors, in order to calculate the area of a survey, first protract it; then dividing the plot into triangles and trapeziums by lines joining opposite corners, they measure with the scale and dividers, the lengths of such lines and perpendiculars as are requisite for calculating the areas of these. The sum of the areas thus obtained, is the area of the survey. When the survey is carefully protracted, and proper attention is given to take the measures with the utmost precision, this method serves to give a near value of the content; but is by no means to be depended on as equally accurate with the general problems mentioned above.

The area of a field or small tract of land, the corners of which can be seen from one another, may readily be found by means of the chain only. To do this, the lengths of the sides must be measured, and also the length of diagonals joining opposite corners, so as to divide the field into triangles. Or instead of the diagonals, the distances from some assumed point within the field, to the several corners, may be used. Having then all the sides of the several triangles, the area of each may be found; and the sum of these areas will be the area of the tract.

PROBLEM I.

To find the area of a Parallelogram, whether it be a Square, a Rectangle, a Rhombus, or a Rhomboides.

RULE.

Multiply the length by the height or perpendicular breadth, and the product will be the area.*

---

* DEMONSTRATION. Let ABCD (Fig. 68) be a rectangle; and let its length AB and CD, and its breadth AD and BC, be each divided into as many equal parts, as are expressed by the number of times they contain the lineal measuring unit; and let all the opposite points of division be connected by right

Note.—Because the length of a square is equal to its height, its area will be found by multiplying the side by itself.

EXAMPLES.

1. Required the area of a square field, a side of which measures 7.29 four-pole chains.

7.29 Ch.
7.29

6561
1458
5103

10)53.1441 Area 5 A. 1 R. 10 P

5.31441
4

1.25764
40

10.30560

2. Required the area of a rectangular field whose length is 13.75 chains, and breadth 9.5 chains.

---

lines. Then, it is evident that these lines divide the rectangle into a number of squares, each equal to the superficial measuring unit; and that the number of these squares is equal to the number of lineal measuring units in the length, as often repeated as there are lineal measuring units in the breadth, or height; that is, equal to the length multiplied by the breadth. But the area is equal to the number of squares or superficial measuring units; and therefore the area of a rectangle is equal to the product of the length and breadth.

Again, a rectangle is equal to any oblique parallelogram of an equal length and perpendicular height (36.1;) therefore the area of every parallelogram is equal to the product of its length and height.

13.75 Ch.
9.5

6875
12375

10)130.625 Area 13 A. 0 R. 10 P.

13.0625
4

.2500
40

10.0000

3. Required the area of a field, in the form of a rhomboides, whose length AB is 42.5 perches, and perpendicular breadth CD is 32 perches. Fig. 15.

42.5 P.
32

850
1275

4|0)136|0.0

4)34

8 A. 2 R.

4. What is the area of a square tract of land whose side measures 176.4 perches? *Ans.* 194 A. 1 R. 36.96 P.

5. What is the area of a rectangular plantation whose length is 52.25 chains, and breadth 38.24 chains?
Ans. 199 A. 3 R. 8.6 P.

6. The length of a field, in the form of a rhombus, measures 16.54 chains, and the perpendicular breadth 12.37 chains: required the area. *Ans.* 20 A. 1 R. 33.6 P.

7. Required the area of a field in the form of a rhomboides, whose length is [illegible]1.16 chains, and perpendicular breadth 11.32 chains. *Ans.* 23 A. 3 R. 32.5 P.

PROBLEM II.

To find the area of a triangle when the base and perpendicular height are given.

RULE.

Multiply the base by the perpendicular height, and half the product will be the area.*

EXAMPLES.

1. The base AB of a triangular piece of ground, measures 12.38 chains, and the perpendicular CD 6.78 chains: required the area. Fig. 49.

12.38 Ch.
6.78
———
9904
8666
7428
———
2)83.9364
———
10)41.9682 Area, 4 A. 0 R. 31 P.
———
4.19682
4
———
.78728
40
———
31.49120

---

* DEMONSTRATION. A triangle is half a parallelogram of the same base and altitude, (41.1) and therefore the truth of the rule is evident.

2. Required the area of a triangular field, one side of which measures 18.37 chains, and the distance from this side to the opposite angle, 13.44 chains.

Ans. 12 A. 1 R. 15 P.

3. What is the area of a triangle whose base is 49 perches and height 34 perches? *Ans.* 5 A. 0 R. 33 P.

PROBLEM III.

To find the area of a triangle when two sides and their included angle are given.

RULE.

As radius,
Is to the sine of the included angle;
So is the rectangle of the given sides,
To double the area.*

EXAMPLES.

1. In a triangular lot of ground ABC, the side AB measures 64 perches, the side AC 40.5 perches, and their contained angle CAB 30°: required the area. Fig. 49.

---

* DEMONSTRATION. In the triangle ABC, Fig. 49, let AB and AC be the given sides, including the given angle A, and let CD be perpendicular on AB. Then by trig. rad. : sin. A : : AC : CD; but (cor. 1.6) AC : CD : : AC×AB : CD×AB; therefore (11.5) rad. : sin. A : : AC×AB : CD×AB; but CD×AB is equal to twice the area of the triangle : hence the truth of the rule is evident.

As radius	- - - - - - - -	10.00000
Is to sin. A, 30°	- - - - - -	9.69897
So is AB, AC	64 - - - -	1.80618
	40.5 - - -	1.60746
		13.11261
To double the area 1296 perches		3.11261

4|0)64|8

4)16 8

4 A. 0 R. 8 P.

2. What is the area of a triangle, two sides of which measure 15.36 chains and 11.46 chains respectively, and their included angle 47° 30′? *Ans.* 6 A. 1 R. 38 P.

3. One side of a triangular field bears N. 12° E. distance 18.23 chains, and at the same station the other adjacent side bears N. 78° 30′ E. distance 13.84 chains: required the area. *Ans.* 11 A. 2 R. 11 P.

4. Required the area of a triangular piece of ground, one side of which bears N. 82° 30′ W. dist. 19.74 chains, and at the same station the other adjacent side S. 24° 15′ E. dist. 17.34 chains. *Ans.* 14 A. 2 R. 8 P.

PROBLEM IV.

To find the area of a triangle when one side and the two adjacent angles are given.

RULE.

Subtract the sum of the two given angles from 180°; the remainder will be the angle opposite the given side. Then,

As the rectangle of radius and the sine of the angle
opposite the given side,
Is to the rectangle of the sines of the other angles,
So is the square of the given side,
To double the area.*

EXAMPLES.

1. In a triangular field ABC, the side AB measures 76 perches, the angle A 60°, and the angle B 50°: required the area. Fig. 47.

The angle ACB=180° — the sum of the angles A and B,=70°.

As rad. × sin. C,	rad. sin. C. 70°	Ar. Co. 0.00000 Ar. Co. 0.02701
: sin. A × sin. B,	sin. A. 60° sin. B. 50°	9.93753 9.88425
: : AB^2 = AB × AB,	AB 76 AB 76	1.88081 1.88081
: double area in perches	4078	3.61041

40)2039

4)50 39

12 A. 2 R. 39 P.

---

* DEMONSTRATION. Let AB, Fig. 49, be the given side of the triangle ABC, and A and B the given angles; also let CD be perpendicular on AB: Then by trig.

sin. ACB : sin. B. : : AB : AC
rad. : sin. A : : AC : CD.

Therefore (23.6) rad. × sin. ACB : sin A × sin. B : : AB × AC : CD × AC : : (Cor. 1.6) AB : CD : : AB^2 : AB × CD; but AB × CD is equal to double the area of the triangle ABC; therefore (11.5) rad. × sin. ACB : sin. A × sin. B : : AB^2 : double the area of the triangle ABC.

2. One side of a triangle measures 24.32 chains, and the adjacent angles are 63° and 74°: required the ar[illegible]
Ans. 37 A. 0 R. 22 P.

3. What is the area of a triangular field, one side of which is 17.36 chains, and the adjacent angles 37° 30′, and 48° 15′? *Ans.* 6 A. 3 R. 18 P.

PROBLEM V.

To find the area of a triangle when the three sides are given.

RULE.

From half the sum of the three sides subtract each side severally; multiply the half sum and the three remainders continually together, and the square root of the last product will be the area.[*]

---

[*] DEMONSTRATION. Let ABC, Fig. 69, be the triangle. Bisect any two of the angles, BAC, ABC, by the straight lines AG, BG, meeting in G; let fall on the three sides of the triangle, the perpendiculars GD, GF, GE, and join GC; also produce AB, AC, and bisect one of the exterior angles, HBC, by the line BK, meeting AG[*] produced in K, join KC, and let fall the perpendiculars KH, KM, and KL. Then (26.1) AD is equal to AE and DG to GE; also BD is equal to BF, and DG to GF; hence GF and GE are equal, and consequently (47.1) CF is equal to CE. In like manner it may be proved that AH is equal to AL, BH to BM, and CM to CL; as likewise that KH, KM, and KL are equal to each other. Now since BH is equal to BM and CL to CM, it is manifest that AH and AL together, are equal to the sum of the three sides AB, AC, and BC; hence AH or AL is equal to the semiperimeter of the triangle ABC. But since twice AD, twice BD, and twice CF are, together, equal to the sum of the sides of the triangle, or twice AH, it is ob-

[*] The angle BAC is less than the angle HBC (16.1 ;) consequently BAG is less than HBK, and BAG, KBA, are together less than HBK, KBA; but HBK, KBA, are together equal to two right angles; hence BAG, KBA, are less than two right angles; therefore (cor. 29.1) the line BK will meet the line AG produced.

EXAMPLES.

1. Required the area of a triangular tract of land, whose three sides are 49.00, 50.25 and 25.69 chains.

---

vious that AD, BD and CF together, are equal to AH; consequently CF is equal to BH or BM; hence CM or CL is equal to BF or BD; and therefore DH and BC are equal.

Hence, if from the semiperimeter AH, the three sides AB, AC and BC be severally taken, the remainders will be BH, CL, (or BD) and AD respectively.

Again, since the angles DBF and DGF are together equal to two right angles, as likewise DBF and FBH together equal to two right angles, it is manifest that the angle DGF is equal to the angle HBF; and the angle DGB to the angle HBK; the triangles DBG and HKB are therefore similar. Hence BD : DG : : KH : HB; also in the similar triangles ADG, AHK, AD : DG : : AH : HK; therefore (23.6) AD × BD : DG^2 : : AH : HB : : AH^2 : AH × HB.

If therefore we take between AD and BD, and between AH and HB, the mean proportionals M and N respectively, the foregoing analogy will become $M^2 : DG^2 :: AH^2 : N^2$; hence (22.6) M : DG : : AH : N; consequently the rectangle M × N is equal to the rectangle AH × DG; therefore ABC=ABG+BCG+ACG=AH × DG=M × N=$\sqrt{(AD \times BD)} \times \sqrt{(AH \times HB)} = \sqrt{(AD \times BD \times HB \times AH.)}$

	49.00		
	50.25		
	25.69		
Sum	124.94		
Half sum	62.47	log.	1.79567
Remainders	13.47		1.12937
	12.22		1.08707
	36.78		1.56561
			2)5.57772
	615 chains		2.78886
	61.5 Acres=61 A. 2 R.		

2. What is the area of a triangular field whose sides measure 10.64, 12.28, and 9.00 chains?

Ans. 4 A. 2 R. 26 P.

3. What quantity of land is contained in a triangle, the sides of which are 20, 30 and 40 chains?

Ans. 29 A. 0 R. 7 P

PROBLEM VI.

To find the area of a trapezium, when one of the diagonals and the two perpendiculars, let fall on it from the opposite angles, are given.

RULE.

Multiply the sum of the perpendiculars by the diagonal, and half the product will be the area.*

---

* DEMONSTRATION. The area of the triangle ABC (Fig. 70)= $\frac{AC\times BF}{2}$; and the area of the triangle ADC= $\frac{AC\times DE}{2}$; therefore the sum of these

Note. When all the sides and one of the diagonals are given, the trapezium will be divided into two triangles, the area of each of which may be found by the last problem. The sum of these areas will be the area of the trapezium.

EXAMPLES.

1. In a field ABCD, in the form of a trapezium, the diagonal AC measures 20.64 chains, the perpendicular BF 6.96 chains, and DE 5.92 chains; required the area. Fig. 70.

```
     Ch.
     6.96
     5.92
    -----
    12.88
    20.64
    -----
     5152
    7728
   2576
  -------
2)265.8432
  --------
  132.9216 Ch.=13 A. 1 R. 6 P.
```

2. Required the area of a trapezium whose diagonal measures 16.10 ch. and the perpendiculars 6.80 ch. and 3.40 ch. *Ans.* 8 A. 0 R. 33¾ P.

3. The diagonal of a trapezium is 24 ch. and the perpendiculars are 8.27 ch., and 12.43 ch.; what is the area? *Ans.* 24 A. 3 R. 14 P.

---

areas, or the area of the trapezium ABCD$=\frac{AC\times BF}{2}+\frac{AC\times DE}{2}=\frac{BF+DE}{2}\times AC$.

PROBLEM VII.

To find the area of a trapezium, when all the angles and two opposite sides are given.

Note.—*When three of the angles are given, the fourth may be found, by subtracting their sum from* 360°.

RULE.

Consider one of the given sides and its adjacent angles, or their supplements when their sum exceeds 180°, as the side and adjacent angles of a triangle, and find its double area by prob. 4. Proceed in the same manner with the other given side and its adjacent angles: Half the difference of the areas thus found will be the area of the trapezium.*

EXAMPLES.

1. In a four-sided field ABCD, there are given the following bearings and distances, viz. AB, N. 24° E. dist. 6.90 ch.; BC, N. 64° 40′ E.; CD, S. 35° 20′ E. dist. 11.50 ch.; and DA, S. 88° W.: required the area. Fig. 71.

From the given bearings, the angles may be found as follows:

AD, N. 88° E.	CB, S. 64° 40′ W.
AB, N. 24 E.	CD, S. 35 20 E.
BAD=64°	BCD=100° 00

---

* **Demonstration.** Let AB, CD, Fig. 71, be the given sides of the trapezium ABCD. Produce DA, CB, to meet in E; then 2ABCD=2EDC—2EAB or $ABCD=\frac{2EDC-2EAB}{2}$. Hence the truth of the rule is evident.

BC, N. 64° 40′ E.		DC, N. 35° 20′ W.	
BA, S. 24 00 W.		DA, S. 88 00 W.	
	40 40		123 20
	180 00		180 00
ABC=	139 20	ADC=	56 40

Construction.

Make AB=6.90, and draw DA, CB, making the angle DAB=64°, and ABC=139° 20′; produce DA and make the angle EAF=56° 40′=the given angle ADC; lay off AF=11.50=the given side BD, and parallel to AD draw FC, meeting BC in C; lastly draw CD parallel to AF, meeting AD in D; then will ABCD be the trapezium.*

Calculation.

The angle E=180° — the sum of the angles BCD, ADC=23° 20′.

As rad. × sin. E,	rad.	Ar. Co.	0.00000
	sin. E. 23° 20′	Ar. Co.	0.40222
: sin. EAB × sin. EBA,	sin. EAB 116° 00′		9.95366
	sin. EBA 40° 40′		9.81402
: : AB²,	AB 6.90		0.83885
	AB 6.90		0.83885
: 2 EAB 70.405			1.84760

---

* Demonstration. By construction FC is parallel to AD and CD to AF; therefore (34.1) CD=AF and (29.1) the angle ADC=EAF; hence it is evident that the sides AB, CD, and the angles of the trapezium ABCD are respectively equal to the given sides and angles.

As rad × sin. E,	rad.	Ar. Co.	0.00000
	sin. E. 23° 20′	Ar. Co.	0.40222
: sin. ECD × sin. EDC,	sin. ECD 100° 00′		9.99335
	sin. EDC 56 40		9.92194
: : CD^2,	CD 11.50		1.06070
	CD 11.50		1.06070
: 2 EDC 274.731			2.43891

2 EAB 70.405

2ABCD 204.326
ABCD=102.163 Ch.=10 A. 0 R. 34.6 P.

2. In a trapezium ABCD, the angles are, A=65°, B =81°, C=120°, and consequently D=94°; also the side AB=20 ch. and CD=11 ch.: required the area.
Ans. 22 A. 2 R. 27 P.

3. Required the area of a four-sided piece of land, bounded as follows:

1. N. 12° 30′ E.
2. N. 81 00 E. dist. 23.20 ch.
3. S. 36 00 W.
4. N. 89 00 W. dist. 12.90 ch.

Ans. 27 A. 2 R. 24 P.

PROBLEM VIII.

To find the area of a trapezium when three sides and the two included angles are given.

RULE.

As radius,
Is to the sine of one of the given angles;
So is the rectangle of the sides including this angle,
To a certain quantity.

As radius,
Is to the sine of the other given angle;
So is the rectangle of the sides including this other angle,
To a second quantity.

Take the difference between the sum of the given angles and 180°; Then,

As radius,
Is to the sine of this difference;
So is the rectangle of the opposite given sides,
To a third quantity.

If the sum of the angles be less than 180°, subtract the third quantity from the sum of the other two, and half the difference will be the area of the trapezium. But if the sum of the given angles exceed 180°, add all the three quantities together, and half the sum will be the area.*

---

* DEMONSTRATION. Let ABCD (Fig. 72 or 73) be the trapezium, having the given sides, AD, AB, BC, and given angles DAB, ABC. Complete the parallelograms ABCE, ABFD, and join ED, CF; then because EC, DF, are each parallel and equal to AB, they are (30.1) parallel and equal to each other, and (33.1) ECFD is a parallelogram; therefore ABFD=ABHG+GHFD =(35.1.) ABCE+ECFD=(34.1.) ABCE+2ECD; to the first and last of these equals add ABCE, then ABFD+ABCE=2ABCE+2ECD=2ABCDE.

But, Fig. 72, when the sum of the given angles DAB, ABC, is less than 180°, 2ABCDE=2ABCD+2EAD; therefore in this case ABFD+ABCE= 2ABCD+2EAD; or ABFD+ABCE—2EAD=2ABCD.

And, Fig. 73, when the sum of the given angles DAB, ABC, exceeds 180°, 2ABCDE=2ABCD—2EAD; therefore ABFD+ABCE=2ABCD—2EAD; or, ABFD+ABCE+2EAD=2ABCD.

But by prob. 3. one of the first two proportions gives 2BAD (=ABFD,) and the other gives 2ABC (=ABCE;) also because the angle EAD is the

EXAMPLES.

1. In a trapezium ABCD, there are given AD=23.32 ch., AB=25.70 ch., and BC=15.84 ch., the angle DAB=64°, and ABC=82°: required the area.

As rad. - - - - - - -	Ar. Co.	0.00000
: sin. DAB, 64° - - - -		9.95366
: : AD×AB,	AD 23.32 - -	1.36773
	AB 25.70 - -	1.40993
: first quantity 538.66 - - -		2.73132

As rad. - - - - - - -	Ar. Co.	0.00000
: sin. ABC, 82° - - - - -		9.99575
: : AB×BC,	AB 25.70 -	1.40993
	BC 15.84 -	1.19975
: second quantity 403.12 -		2.60543

DAB	64°
ABC	82
	146
	180
Difference	34°

As rad. - - - - - - -	Ar. Co.	0.00000
: sin. difference 34° - - - -		9.74756
: : AD×BC,	AD 23.32 - -	1.36773
	BC 15.84 - -	1.19975
: third quantity 206.55 - - -		2.31504

---

difference between the sum of the given angles and 180°, and the side EA=BC, the third proportion gives 2EAD : hence the truth of the rule is manifest.

1st quantity 538.66
2d " 403.12
941.78
3d " 206.55
2)735.23
367.615 ch.=36 A 3 R. 2 P.

2. What is the area of a four-sided lot of ground, three sides of which, taken in order, measure 6.15, 8.46, and 7.00 chains, respectively; the angle contained by the first and second sides 56°, and that contained by the second and third sides 98° 30′? *Ans.* 4 A. 0 R. 25 P.

3. One side of a quadrilateral piece of land bears S. 7¼ E. dist. 17.53 ch., the second, N. 87 E. dist. 10.80 ch. and the third, N. 25¾ E. dist. 12.92 ch.: what is the area? *Ans.* 21 A. 3 R. 2 P.

PROBLEM IX.

To find the area of a trapezoid.

RULE.

Multiply the sum of the parallel sides by their perpendicular distance, and half the product will be the area.*

EXAMPLES.

1. Required the area of a trapezoid ABCD, of which the parallel sides AD, BC measures 6.14 and 9.48 chains,

---

* DEMONSTRATION. The trapezoid ABCD, Fig. 74,=the triangle ABD+BDC=(by prob. 2,) $\frac{AD\times BF}{2}+\frac{BC\times DE}{2}$,=(because BF=DE,) $\frac{AD\times BF}{2}+\frac{BC\times BF}{2}=\frac{\overline{AD+BC}\times BF.}{2}$

respectively, and their perpendicular distance BF or DE, 7.80 chains.

Ch.
6.14
9.48
———
15.62
7.80
———
124960
10934
———
2)121.8360
———
60.9180 Ch.=6 A. 0 R. 15 P.

2. The parallel sides of a trapezoid are 12.41 and 8.22 chains, and their perpendicular distance 5.15 chains: required the area. *Ans.* 5 A. 1 R. 10 P.

3. Required the area of a trapezoid whose parallel sides are 11.34 and 18.46 chains, and their perpendicular distance 13.25 chains. *Ans.* 19 A. 2 R. 39 P

PROBLEM X.

To find the area of a circle, or of an ellipsis.[*]

RULE.

Multiply the square of the circle's diameter, or the product of the two diameters of the ellipsis, by .7854, for the area.*

---

[*] If two pins be set upright in a plane, and a thread, the length of which is greater than twice the distance between the pins, having the ends tied together, be put about the pins; and if the point of a pin or pencil applied to the thread, and held so as to keep it uniformly tense, be moved round, till it return to the place from which the motion began; then the point of the pin or pencil will have described on the plane, a curved line called an *Ellipsis.*

Note 1.—If the diameter of a circle be multiplied by 3.1416, the product will be the circumference; also if the circumference be divided by 3.1416, the quotient will be the diameter.

2. If the area of a circle be divided by .7854, the square root of the quotient will be the diameter.

EXAMPLES.

1. How many acres are in a circle a mile in diameter?

1 mile=80 ch.
80
6400
.7854
3141600
47124
5026.5600 Sq. Ch.=502 A. 2 R. 25 P. nearly

Or by Logarithms.

Square of 80	{ 80 80	log. 1.90309 1.90309
	.7854	—1.89509
5026.56 Sq. Ch.		3.70127

2. Required the area of an ellipsis, the longer diameter of which measures 5.36 ch. and the shorter 3.28 ch.

---

* The demonstration of this rule is too abstruse to admit of a place in this work. The student who wishes to see a demonstration is referred to a treatise on *Mensuration* or *Fluxions*.

$$\begin{array}{r}
\text{Ch.} \\
5.36 \\
3.28 \\
\hline
4288 \\
1072 \\
1608 \\
\hline
17.5808 \\
.7854 \\
\hline
703232 \\
879040 \\
1406464 \\
1230656 \\
\hline
13.80796032
\end{array}$$

13.80796032 Sq. Ch. = 1 A. 1 R. 20.9 P.

PROBLEM XI.

The bearings and distances of the sides of a tract of land being given to calculate the area.

RULE.

1. Rule a table and head it as in the annexed example; observing that the letters E. D. D. and W. D. D., stand for *East Double Departure*, and *West Double Departure*.

2. Find by prob. 12. chap. 1., the corrected differences of latitude and the departures, corresponding to the several sides, placing them in their proper places in the table.

3. When the departures corresponding to the first and last sides are of the *same* name, *add* them together, and place the sum opposite the first side, in the column of double departures, which is of *that* name; but when they are of *different* names, take their *difference*, and place it

in the column of double departures, which is of the same name with the *greater* departure. Proceed in the same manner with the departures corresponding to the first and second sides, placing the result opposite the second side; with those corresponding to the second and third sides, placing the result opposite the third side; and so on to the last.

4. Commencing with any side of the survey at pleasure, assume any number whatever for a *multiplier* corresponding to that side, and place it in the column of multipliers, opposite to the side, marking it with the letter E, for *east*. If this multiplier and the double departure, corresponding to the next side, are of the *same* name, take their sum for the next multiplier, marking it with *that* name; but if they are of *different* names, take their difference, marking it with the name of the *greater*. Proceed in the same way with this multiplier and the next double departure; and so on till multipliers have been found corresponding to all the sides.

5. Multiply each of the corrected differences of latitude by its corresponding multiplier; and when the multiplier is *east*, place the product in that column of areas, which is of the *same* name with the difference of latitude; but when it is *west*, place the product in the column of areas, which is of a *different* name from that of the difference of latitude.

6. Add up the numbers in the columns of areas, and taking the difference of their sums, divide it by 2; the result will be the area of the survey.*

---

* DEMONSTRATION. Let ABCDEFG, Fig. 79, be a plot of a survey; and let the east and west line AL, represent the assumed multiplier. From the points B and L, draw BM parallel, and LM perpendicular to AL, meeting in

Note 1.—If the double departures have been correctly found, the sums of the numbers in the two columns, will be equal. Also, if the multipliers have been correctly obtained, the sum or difference of the multiplier last found

---

M; and bisect BM by the meridian NS. Draw the other east and west lines, Cc, md, ne, rf, and ug; and also the meridians hk, Bp, Cn, Ds, ur, Fw, and Gx. Then it is evident that the differences of latitude and the departures corresponding to the several sides will be as in the following table. Also according to the rule, $Bh+Av=Bx$, is the double departure corresponding to the first side; $Bh+Cl=Ck$, is that for the second side; $Cl-Dm=Dp$, is that for the third; and so on to the last.

Dist.	N.	S.	E.	W.	E. D. D.	W.D.D	Multipliers.	N. Areas.	S. Areas.
A B	Ah		Bh		Bx		$Aa+Bb$, E	$2Aab$ B	
BC		Bl	Cl		Ck		$Bb+Cc$, E		2 $BbcC$
CD		Cm		Dm	Dp		$Cc+Dd$, E		2 $CcdD$
DE		Dq	Eq			En	$Dd+Ee$, E		2 $DdeE$
EF		Er		Fr		Fs	$Ee+Ff$, E		2 $EefF$
FG	Ft			Gt		Gu	$Ff+Gg$, E	$2Ffg$ G	
GA	Gv		Av		Aw		$Gg+Aa$, E	$2Gga$ A	

By construction, the assumed multiplier $\mathrm{AL}=\mathrm{A}a+a\mathrm{L}=\mathrm{A}a+b\mathrm{M}=\mathrm{A}a+\mathrm{B}b$. By proceeding with this multiplier and the double departures, as directed in the rule, we shall evidently have the other multipliers as represented in the table. It is also plain that the products of the differences of latitude by these multipliers, will be as represented in the columns of north and south areas.

The sum of the north areas is 2 BAGF$fb$B; and the sum of the south areas is 2 BCDEF$fb$B. The difference of these is 2 ABCDEFGA; the half of which is the area of the survey.

The proceeding demonstration may easily be extended to the case in which and the next double departure, according as they are of the same or different names, will be equal to the *assumed* multiplier.

2. It is best, in general, to assume 0, for the first multiplier; as by so doing there is one multiplication less to be performed, and the other multipliers are mostly smaller numbers, than they would otherwise be.

---

the assumed multiplier is so small as to make the meridian NS pass through the survey. Thus, suppose $\mathrm{A}w+\mathrm{HB}$ to be the assumed multiplier, the meridian in this case coinciding with FH. Then the multipliers will be equal to the differences between the above multipliers and the quantity, $wa+b\mathrm{H}$ or its equal $2b\mathrm{H}$. We may therefore represent them, and the products, as in the following table; in which the multipliers are marked, and the products placed, in conformity with the rule.

Dist.	N.	S.	Multipliers.	N. Areas.	S. Areas.
AB	Ah		$(Aa+Bb)-2\,bH$, E.	$2\,AaBb-2wabH$	
BC		Bl	$(Bb+Cc)-2\,bH$, E.		$2\,BbcC-2HbcK$
CD		Cm	$(Cc+Dd)-2\,bH$ E.		$2\,CcdD-2KcdP$
DE		Dq	$(Dd+Ee)-2\,bH$, E.		$2\,DdeE-2PdeQ$
EF		Er	$(Ee+Ff)-2\,bH$, E.		$2\,EefF-2\,QefF$
FG	Ft		$2\,bH-(Ff+Gg)$ W.		$2\,Ffgt-2\,FfgG$
GA	Gv		$2\,bH-(Gg+Aa)$ W.		$2\,tgaw-2\,GgaA$

The sum of the north areas is $2\,\mathrm{A}ab\mathrm{B}-2\,\mathrm{H}baw$: and the sum of the south areas is $2\,\mathrm{BCDEF}fb\mathrm{B}+2\,waf\,\mathrm{F}-2\,\mathrm{H}bf\,\mathrm{F}-2\,\mathrm{AGF}fa=2\,\mathrm{BCDEF}fb\mathrm{B}+2\,waf\mathrm{F}-2\,waf\,\mathrm{F}-2\,\mathrm{H}baw-2\,\mathrm{AGF}fa=2\,\mathrm{BCDEF}fb\mathrm{B}-2\mathrm{H}baw-2\mathrm{AGF}fa=2\mathrm{BCDEF}fb\mathrm{B}-2\,\mathrm{AGF}fa-2\,\mathrm{H}baw$. If now the sum of the north areas be subtracted from that of the south areas, the remainder will be $2\,\mathrm{BCDEF}fb\mathrm{B}-2\,\mathrm{AGF}fa-2\,\mathrm{A}ab\mathrm{B}=2\,\mathrm{BCDEF}fb\mathrm{B}-2\,\mathrm{BAGF}fb=2\,\mathrm{ABCDEFGA}$.

3. Instead of assuming the first multiplier *east*, it might with equal propriety be assumed *west*. Also instead of finding the multipliers from the departures, they might be found in a similar manner, from the differences of latitude; using, in that case, the departures for multiplicands.

4. When one or two bearings or distances are omitted, they may be found by the problems in the last chapter; and in these cases the differences of latitude and departures are to be used as first obtained from the tables, there being no means of correcting them.

EXAMPLES.

1. Given the bearings and distances of the sides of a tract of land as follow: 1st. 40½° E. 31.80 ch.; 2d. N. 54° E. 2.08 ch.; 3d. N. 29¼° E. 2.21 ch.; 4th. N. 28¾° E. 35.35 ch.; 5th. N. 57° W. 21.10 ch.: and 6th. S. 47° W. 31.30 ch.; to the place of beginning. Required the area of the tract.

Sta.	Bearings.	Dist.	N.	S.	E.	W.	Cor. S.	Cor. E.	N.	S.	E.	W.	E.D.D.	W.D.D.	Multipliers.	N. Areas.	S. Areas.
1	S. 40½ E.	31.80		24.18	20.65		.03	.05		24.21	20.70			2.15	0.00 E.		
2	N. 54 E.	2.08	1.23		1.68		.00	.00	1.23		1.68		22.38		22.38 E.	27.5274	
3	N. 29¼ E.	2.21	1.92		1.08		.00	.00	1.92		1.08		2.76		25.14 E.	48.2688	
4	N. 28¾ E.	35.35	31.00		17.00		.04	.05	30.96		17.05		18.13		43.27 E.	1339.6392	
5	N. 57 W.	21.10	11.49			17.69	.02	.03	11.47			17.66		0.61	42.66 E.	489.3102	
6	S. 47 W.	31.30		21.34		22.89	.03	.04		21.37		22.85		40.51	2.15 E.		45.9455
		123.84	45.64	45.52	40.41	40.58	.12	.17	45.58	45.58	40.51	40.51	43.27	43.27		1904.7456	45.9455

45.64
45.52
.12 Er. S.

40.58
40.41
.17 Er. E.

1904.7456
45.9455
2)1858.8001
10)929.40005
92.940005
4
3.760020
40
30.400800

Area 92 A. 3 R. 30 P.

2. Required the area of a tract of land, bounded as follows: 1st. N. 75° E. 13.70 ch.; 2d. N. 20¼° E. 10.30 ch.; 3d. East, 16.20 ch.; 4th. S. 33¼° W. 35.30 ch. 5th. S. 76° W. 16 ch.; 6th. North, 9 ch.; 7th. S. 84

W. 11.60 ch.; 8th. N. 53¼ °W. 11.60 ch.; 9th. N. 36¾° E. 19.36 ch.; 10th. N. 22½° E. 14 ch.; 11th. S. 76¾° E. 12 ch.; 12th. S. 15° W. 10.85 ch.; 13th. S. 18° W. 10.62 ch.; to the place of beginning.

Sta.	Bearing.	Dist.	N.	S.	E.	W.	cor. N.	cor. E.	N.	S.	E.	W.	E.D.D.	W.D.D.	Multipliers.	N. Areas.	S. Areas.
1	N. 75° E.	13.70	3.54		13.24		.02	.02	3.56		13.26		9.99		0.00 E		
2	N. 20½ E.	10.30	9.65		3.61		.01	.01	9.66		3.62		16.88		16.88 E	163.0608	
3	East.	16.20			16.20		.02	.02	.02		16.22		19.84	3.22	36.72 E	.7344	
4	S. 33½ W.	35.20		29.44		19.49	.05	.05		29.39		19.44		34.94	33.50 E		984.5650
5	S. 76 W.	16.00		3.87		15.52	.02	.02		3.85		15.50		15.49	1.44 W	5.5440	
6	North.	9.00	9.00				.01	.01	9.01		.01			11.51	16.93 W		152.5393
7	S. 84 W.	11.60		1.21		11.54	.02	.02		1.19		11.52		20.79	28.44 W	33.8436	
8	N.53¼ W.	11.60	6.94			9.29	.02	.02	6.96			9.27			49.23 W		342.6408
9	N. 36¾ E.	19.36	15.51		11.59		.03	.02	15.59		11.61		2.34		46.89 W		728.6706
10	N. 22½ E.	14.00	12.93		5.36		.02	.02	12.95		5.38		16.99		29.90 W		387.2050
11	S. 76¾ E.	12.00		2.75	11.68		.02	.02		2.73	11.70		17.08		12.82 W	34.5986	
12	S. 15 W.	10.85		10.48		2.81	.02	.01		10.46		2.80	8.90		3.92 W	41.0032	
13	S. 18 W.	10.62		10.10		3.28	.02	.01		10.08		3.27		6.07	9.99 W	100.6992	
		190.53	57.57	57.85	61.68	61.93	.28	.25	57.70	57.70	61.80	61.80	92.02	92.02		379.8838	2595.6207
				57.57		61.68											379.8838
				.28 Er. N.		.25 Er. E.											2)2215.7369
													Area 110 A. 3 R. 6 P.			Sq. Ch.	1107.8684

3. Given the boundaries of a tract of land as follow, *viz.* 1st. S. 35¼° W. 11.20 ch.; 2d. N. 45° W. 24.36 ch.; 3d. N. 15½° E. 10.80 ch.; 4th. S. 77° E. 16. ch.; 5th. N 87½° E. 21.50 ch.; 6th. S. 60° E. 14.80 ch.; South 10.91 ch.; 8th. N. 85° W. 29.28 ch.; to the place of beginning· required the area. *Ans.* 85 A. 3 R. 17 P.

4. Given the boundaries of a tract of land as follow, *viz.* 1st. N. 19° E. 27 ch.; 2d. S. 77° E. 22.75 ch.; 3d. S. 27° E. 28.75 ch.; 4th. S. 52° W. 14.50 ch.; 5th. S. 15½° E. 19 ch.; 6th. West, 17.72 ch.; 7th. N. 36° W. 11.75 ch.; 8th. North, 16.07 ch.; 9th. N. 62° W. 14.88 ch.; to the place of beginning: required the area.

Ans. 152 A. 2 R. 6 P.

5. Required the area of a tract of land bounded as follows: 1st. S. 62° W. 7.57 ch.; 2d. N. 43½° W. 5.89 ch.; 3d North, 5.82 ch.; 4th. N. 33½° W. 8.83 ch.; 5th. N. 48° E. 4.81 ch.; 6th. N. 12° E. 4.66 ch.; 7th. N. 62½° E. 5.27 ch.; 8th. S. 6½° E. 5.60 ch.; 9th. S. 40½° E. 5.87 ch.; 10th. East, 6.54 ch.; 11th. North, 5.52 ch.; 12th. N. 68¼° E. 3.10 ch.; 13th. S. 30° E. 7.90 ch.; 14th. S. 23° W. 8.80 ch.; 15th. S. 31½° E. 6.42 ch.; 16th. S. 50° W. 8.40 ch.; 17th. N. 44° W. 6.85 ch. to the place of beginning.

Ans. 44 A. 2 R. 22 P.

6. Given the following field-notes to find the area of the survey; also the bearings and distance of the 3d side, which were omitted to be taken on account of obstacles in the way.

		Ch.
1.	S. 85¼° E.	23.30
2.	S. 19 E.	31.12
3.	——	——
4.	N. 64 W.	29.72

		Ch.
5. N. 15½°	W.	22.46
6. N. 58	E.	25.94
7. S. 27¾	E.	6.60

Ans. Area 182 A. 0 R. 21.7 P. and the bearing and distance of the 3d side, S. 66° 23′ W. 28.06 ch.

7. Being furnished with the field-notes of a tract of land, and requested to calculate the area, I found on examining them, that the figures expressing the angles of bearing of the 4th and 5th sides were so defaced as to be illegible: but as the remaining data are sufficient, the area is required. The field notes are as follow:

		Ch.
1. S. 60¾°	W.	10.34
2. N. 27¼	W.	17.88
3. N. 51	E.	15.85
4. N. —	E.	9.61
5. S. —	E.	19.18
6. S. 16¾	E.	22.21
7. S. 71½	W.	16.66
8. N. 71¼	W.	5.76

Ans. 81 A. 2 R. 23 P.

8. In a survey, represented Fig. 81, the corner at A was inaccessible, occasioned by the overflowing of water; but being a tree, it can be seen from the adjacent corners B and L. I therefore set my instrument at B and took the bearing to A, which I reversed, and set in my field-book as the first bearing. I then proceeded to take the bearings and distances of the several sides to L; and at L, I took the bearing of the side LA. The field-notes being as follow, the length of the sides AB and LA, and the area are required.

		Ch.
AB,	N. 51¼° W.	
BC,	S. 45½ W.	15.16
CD,	N. 50 W.	22.10
DE,	North,	18.83
EF,	N. 48 E.	22.60
FG,	N. 25½ W.	20.17
GH,	East,	26.57
HI,	S. 30½ E.	22.86
IK,	S. 44 W.	15.04
KL,	S. 47 E.	28.55
LA,	S. 20½ W.	

Ans. AB, 26.47 ch.; LA, 23.81 ch.; and the area 244 A. 3 R. 13 P.

9. In taking a survey of a tract of land bounded by six straight sides, Fig. 80, I was prevented going directly from the 3d to the 4th corner by a pond of water. I therefore set up two stakes near the edge of the pond, and took the bearing and distance from the 3d corner to the first stake, from the first stake to the second, and from the second to the 4th corner, and noted them in my field book as all belonging to the 3d station of the survey. The field-notes being as follow, the bearing and distance of the 3d side, and the area of the survey are required.

1.	North,	7.81 Ch.
2.	S. 76¼° E.	18.15
3.	S. 52 W.	10.70
	S. 7½ W.	13.92
	S. 33¼ E.	9.00
4.	N. 84¼ W.	27.12
5.	N. 4½ W.	22.00
6.	East,	16.58

Ans. 3d side, S. 10° 47′ W. 28.42 ch.; and area 80 A. 0 R. 25 P.

PROBLEM XII.

To find the area, when off-sets are taken.

RULE.

1. Find by the last problem, the area enclosed by the stationary lines and straight sides of the survey.

2. Subtract the stationary distance of each off-set, from that of the one immediately following; the remainders will be the distances, intercepted on the stationary line, between each two adjacent off-sets. Place these under one another in a column as in the annexed examples. Also take the sums of each two adjacent off-sets, and place them in the next column, so as to correspond with the intercepted distances.

3. Multiply the sum of each two adjacent off-sets by their intercepted distance on the stationary line; then, half the sum of the products will be the area of the off sets on that line.

4. If there are off-sets on more than one stationary line, proceed in the same manner with the others.

5. When the stationary lines are within the boundary of the survey, add the areas of the off-sets to the area enclosed by the stationary lines and straight sides; but when the stationary lines are without the boundary, subtract the areas of the off-sets.*

---

* DEMONSTRATION. Considering the boundary as straight between the ends of each two adjacent off-sets, it is plain that the area contained between the stationary line and boundary will be divided by the off-sets into trapezoides and triangles. Hence the truth of the rule is evident.

EXAMPLE 1. Fig. 82.

Required the area of a piece of a meadow, bounded on one side by a brook; the field-notes being as follow:

	Left-hand off-sets on the stat. line.		
	Sta.	Dist.	Off-sets.
1. N. 16½° E. 14.35 Ch.	No. 1.	0.00 Ch.	0.30 Ch.
2. East, 7.82	2.	0.95	0.84
3. S. 3½ W. 14.45 Stat. line.	3.	2.03	0.86
4. N. 86½ W. 11.07	4.	3.28	0.50
	5.	5.20	1.80
	6.	7.43	2.35
	7.	8.98	1.45
	8.	10.46	1.08
	9.	11.71	1.85
	10.	14.45	0.35

The area of the part ABCD will be found, by the last problem, to be 13 A. 1 R. 11 P.

To find the area of the off-sets.

No.	Sta. Dist. Ch.	Off-sets. Ch.	Intercep. Dist.	Sums of Off-sets.	Products.
1	0.00	0.30			
2	0.95	0.84	0.95	1.14	1.0830
3	2.03	0.86	1.08	1.70	1.8360
4	3.28	0.50	1.25	1.36	1.7000
5	5.20	1.80	1.92	2.30	4.4160
6	7.43	2.35	2.23	4.15	9.2545
7	8.98	1.45	1.55	3.80	5.8900
8	10.46	1.08	1.48	2.53	3.7444
9	11.71	1.85	1.25	2.93	3.6625
10	14.45	0.35	2.74	2.20	6.0280

2)37.6144

18.8072 Ch.
=1 A. 3 R. 21 P.

	A.	R.	P.
Area of ABCD	13	1	11
Do. of off-sets	1	3	21
Whole area	15	0	32

EXAMPLE 2. Fig. 83.

Required the area of a survey from the following field notes.

		Ch.	
1. N. 36¾°	W.	30.00	
2. N. 56¼	E.	21.60	stat. line.
3. N. 26½	E.	13.44	Do.
4. S. 71½	E.	18.96	Do.
5. S. 26½	E.	13.46	Do.
6. S. 45	W.	42.41	

Left hand off-sets.

1st. Stationary Line.			3d Stat. Line.		
Sta. No.	Dist. Ch.	Off-sets. Ch.	Sta. No.	Dist. Ch.	Off-sets. Ch.
1.	0.00	0.50	1.	0.00	0.55
2.	6.10	3.40	2.	4.20	2.50
3.	10.15	3.10	3.	8.05	3.20
4.	14.08	3.96	4.	15.15	2.45
5.	19.20	2.70	5.	18.96	0.50
6.	21.60	0.55	4th Stat. Line.		
2d. Stat. Line.			1.	0.00	0.50
1.	0.00	0.55	2.	5.12	2.75
2.	13.44	0.55	3.	10.00	1.90
			4.	13.46	0.70

The area within the stationary lines and straight sides, found by the last problem, is 1152.5381 square chains.

To find the area of the off-sets.

1st. Stationary Line.

No.	Sta. Dist. Ch.	Off-sets. Ch.	Intercep. Dist.	Sums of Off-sets.	Products.
1	0.00	0.50			
2	6.10	3.40	6.10	3.90	23.7900
3	10.15	3.10	4.05	6.50	26.3250
4	14.08	3.96	3.93	7.06	27.7458
5	19.20	2.70	5.12	6.66	34.0992
6	21.60	0.55	2.40	3.25	7.8000

2d. Stationary Line.

No.	Sta. Dist. Ch.	Off-sets. Ch.	Intercep. Dist.	Sums of Off-sets.	Products.
1	0.00	0.55			
2	13.44	0.55	13.44	1.10	14.7840

3d. Stationary Line.

No.	Sta. Dist. Ch.	Off-sets. Ch.	Intercep. Dist.	Sums of Off-sets.	Products.
1	0.00	0.55			
2	4.20	2.50	4.20	3.05	12.8100
3	8.05	3.20	3.85	5.70	21.9450
4	15.15	2.45	7.10	5.65	40.1150
5	18.96	0.50	3.81	2.95	11.2395

4th. Stationary line.

1	0.00	0.50			
2	5.12	2.75	5.12	3.25	16.6400
3	10.00	1.90	4.88	4.65	22.6920
4	13.46	0.70	3.46	2.60	8.9960

2)268.9815

Area of the off-sets - - - - - 134.49075 Ch.

Area within the stationary lines - 1152.5381

1287.02885 Ch.

128.702885 Acr
4

2.811540
40

32.46160

Area of the survey, 128 A. 2 R. 32 P.

EXAMPLE 3.

Required the area of a meadow from the following field notes.

			Left-hand off-sets on the stat. line.		
			Sta.	Dist.	Off-sets.
1. N. 41¼° E.	14.35 Ch.		No. 1.	0.00 Ch.	0.38 Ch
2. S. 42¼ E.	14.71	Sta. line.	2.	2.65	2.35
3. S. 54 W.	16.32		3.	3.80	1.70
4. N. 32¼ W.	11.50		4.	6.00	2.75
			5.	7.50	1.40
			6.	9.60	3.20
			7.	12.38	2.72
			8.	14.71	0.42

Ans. Area 22 A. 3 R. 27 P.

EXAMPLE 4.

The following field-notes are given, to find the area of the survey.

			Left-hand off-sets.					
			On the 1st. stat. line.			On the 2d. stat. line.		
			Sta.	Dist.	Off-sets.	Sta.	Dist.	Off-sets.
	Ch.		No.	Ch.	Ch.	No.	Ch.	Ch.
1. S. 69½° E.	16.14	sta. line	1.	0.00	0.44	1.	0.00	0.31
2. S. 28 E.	9.38	Do.	2.	3.80	2.00	2.	2.67	2.94
3. S. 32¾ W.	21.20		3.	7.04	3.79	3.	6.20	2.62
4. N. 48 W.	22.47		4.	9.87	2.34	4.	9.38	0.39
5. N. 26¾ E.	19.00		5.	13.24	3.00			
			6.	16.14	0.31			

Ans. 56 A. 2 R. 18P.

PROBLEM XIII.

Given the bearing and distance of two stations from each other and the bearings of all the corners of a tract of land from these stations, to find the area of the tract.

The method of doing this will be best explained by an example.

Example 1.

Let ABCDEFGA, *Fig.* 84, represent a field, all the angles of which can be seen from two stations, H and I, without it. The bearing and distance of the stations, and the bearings of all the angles of the field, from each station, being as follow, it is required to find the area.

The station H bears from the station I, North, dist. 28 ch.

	Bearings.		Bearings.
HA	S. 81½° E.	IA	N. 28½° E.
HB	S. 85¾ E.	IB	N. 42¼ E.
HC	S. 68 E.	IC	N. 51½ E.
HD	S. 58¼ E.	ID	N. 71 E.
HE	S. 35½ E.	IE	S. 82½ E.
HF	S. 28½ E.	IF	N. 73½ E.
HG	S. 40 E.	IG	N. 60 E.

Construction.

Draw HI according to the given bearing and distance; and from the points H and I, draw HA, HB, HC, &c.

and IA, IB, IC, &c. according to the given bearings; then will the intersections A, B, C, &c. of the corresponding bearings HA and IA, HB and IB, HC and IC, &c. be the angular points of the field.

Calculation.

In each of the triangles IHA, IHB, IHC, &c. we have the side IH; and from the bearings of the sides, we have all the angles, to find the sides IA, IB, IC, &c.

Then in each of the triangles, IAB, IBC, ICD, &c. we have two sides, and the included angle; whence the areas may be found by prob. III.

From the sum of the areas of the triangles IAB, IBC, ICD, and IDE, which is equal to the area IABCDEI, subtract the sum of the areas of the triangles IAG, IGF and IFE, which is equal to the area IAGFEI; the remainder will be the area of the field ABCDEFGA.

Note.—In working the proportions for finding the sides IA, IB, &c. it will be unnecessary, when the area only is required, to take out the natural numbers corresponding to the logarithms of those sides; because in the proportions for finding the areas it will be sufficient to know the logarithms of the sides, without knowing their real lengths.

To find the log. of IA.

As sin. HAI, 70° 00′ - - - - - 9.97299
: sin. AHI, 81 30 - - - - - 9.99520
: : IH, 28 - - - - - - - - - - 1.44716

11.44236

: IA, - - - - - - - - log. 1.46937

To find the log. of IB.

As sin. HBI 52° 00′ - - - - - -	9.89653
: sin. BHI 85 45 - - - - - -	9.99880
: : IH 28 - - - - - - - - -	1.44716
	11.44596
: IB - - - - - - - log.	1.54943

To find the log. of IC.

As sin. HCI 60° 30′ - - - - - -	9.93970
: sin. CHI 68 00 - - - - - -	9.96717
: : IH 28 - - - - - - - - -	1.44716
	11.41433
: IC - - - - - - - log.	1.47463

To find the log. of ID.

As sin. HDI 50° 45′ - - - - - -	9.88896
: sin. DHI 58 15 - - - - - -	9.92960
: : IH 28 - - - - - - - - -	1.44716
	11.37676
. ID - - - - - - - - - log.	1.48780

To find the log. of IE.

As sin. HEI 47° 00′ - - - - - -	9.86413
: sin. EHI 35 30 - - - - - -	9.76395
: : IH 28 - - - - - - - - -	1.44716
	11.21111
: IE - - - - - - - log.	1.3[illegible]698

To find the log. of IF.

As sin. HFI 78° 00′		9.99040
: sin. FHI 28 30		9.67866
: : IH 28		1.44716
		11.12582
: IF	log.	1.13542

To find the log. of IG.

As sin. HGI 80° 00′		9.99335
: sin. GHI 40 00		9.80807
: : IH 28		1.44716
		11.25523
: IG	log.	1.26188

To find the double area of the triangle IAB.

As rad.		10.00000
: sin. AIB 13° 45′		9.37600
: : IA × IB, { IA	log.	1.46937
IB	—	1.54943
: 2IAB 248.2		2.39480

To find the double area of the triangle IBC.

As rad.		10.00000
: sin. BIC 9° 15′		9.20613
: : IB × IC, { IB	log.	1.54943
IC	—	1.47463
: 2IBC 169.9		2.20319

To find the double area of the triangle ICD.

As rad. - - - - - - - - - - -		10.00000
: sin. CID 19° 30′ - - - - - -		9.52350
: : IC×ID, { IC - - - - - -	log.	1.47463
{ ID - - - - - -	—	1.48780
: 2ICD, 306.15 - - - - - - -		2.48593

To find the double area of the triangle IDE.

As rad. - - - - - - - - - -		10.00000
: sin. DIE 26° 30′ - - - - - -		9.64953
: : ID×IE, { ID - - - - - -	log.	1.48780
{ IE - - - - - -	—	1.34698
: 2IDE 305.007 - - - - - - - -		2.48431

To find the double area of the triangle IEF.

As rad. - - - - - - - - - - - -		10.00000
. sin. EIF 24° 00′ - - - - - - -		9.60931
: : IE×IF, { IE - - - - - -	log.	1.34698
{ IF - - - - - -	—	1.13542
: 2IEF 123.511 - - - - - - -		2.09171

To find the double area of the triangle IFG.

As rad - - - - - - - - - -		10.00000
: sin. FIG 13° 30′ - - - - - -		9.36818
: : IF×IG, { IF - - - - - -	log.	1.13542
{ IG - - - - - -	—	1.26188
: 2IFG 58.274 - - - - - - - -		1.76548

To find the double area of the triangle IAG.

As rad. - - - - - - - - - -		10.00000
: sin. AIG 31° 30 - - - - - -		9.71809
:: IA×IG,	IA - - - - -	log. 1.46937
	IG - - - - -	—— 1.26188
: 2IAG 281.412 - - - - - -		2.44934

	Ch.
2IAB - - -	248.2
2IBC - - -	169.9
2ICD - - -	306.15
2IDE - - -	305.007
2IABCDEI	1029.257
2IAGFEI	463.197
2ABCDEFGA	566.060
ABCDEFGA	283.03 Ch.=21 A. 1 R. 8 P.

	Ch.
2IEF	123.511
2IFG	58.274
2IAG	281.412
2 IAGFEI	463.197

The bearings and distances of the sides, if required, might readily be obtained. For, having found the distances IA, IB, we have in the triangle IAB, two sides, and an included angle; whence the angle IAB and side AB may be found. The angle IAB applied to the bearing of IA, will give the bearing of AB. In the same manner the bearings and distances of the other sides may be found.

EXAMPLE 2.

Being required to calculate the area of a field, the owner of which refuses permission to go on it, I choose two stations, F and G, in the adjacent land, from whence all the angles of the field are visible. The bearing and distance of the stations, and the bearings of the angles, from each station, are as follow. What is the area of the field?

The station G bears from the station F, N. 43° W. 20 ch.

	Bearings.		Bearings.
FA	N 25½° E.	GA	S. 66° E.
FB	N. 19 W.	GB	N. 23 E.
FC	N. 5 W.	GC	N. 38¼ E.
FD	N. 16 E.	GD	N. 60½ E.
FE	N. 60½ E.	GE	S. 84 E.

Ans. 33 A. 1 R. 7 P.

PROBLEM XIV.

To find the area of a survey by protracting it, and dividing the plot into triangles and trapeziums.

The method of doing this will be easily understood from the following example.

Example 1.

Given the bearings and distances of the sides of a tract of land as follow: 1st. N. 50° E. 9.60 ch.; 2d. S. 32° E. 16.38 ch.; 3d. S. 41° W. 6.30 ch.; 4th. West, 8.43 ch.; 5th. N. 79° W. 10.92 ch.; 6th. N. 5° E. 11.25 ch.; 7th. S. 83° E. 6.48 ch.; to the place of beginning. Required the area.

Fig. 75, is a plot of this survey: and by drawing the lines as in the plot, it is divided into two trapeziums AGFE, AEDF, and a triangle BDC. Measure the several bases and perpendiculars, on the same scale that was used in the protraction, and find the double areas of the triangle and trapeziums by probs. 2 and 6; the sum of these will be the double area of the survey.

$$\begin{array}{lll}
\text{Bases.} & \text{Perpens.} & \\
\text{EG } 16.68\times & \left\{\begin{array}{l}\text{F}a\ 7.50\\ \text{A}b\ 4.71\end{array}\right\} & = 203.6628 = 2\text{ AGFE}\\
\text{EB } 19.17\times & \left\{\begin{array}{l}\text{A}c\ 5.85\\ \text{D}d\ 8.10\end{array}\right\} & = 267.4215 = 2\text{ AEDB}\\
\text{BD } 19.23\times & \text{C}e\ 5.16 & = 99.2268 = 2\text{ BDC}\\
\cline{3-3}
 & & 2)570.3111\text{ ch.} = 2\text{ ABCDEFG}\\
\cline{3-3}
 & & 285.15555\text{ ch.} = 28\text{A. }2\text{R. }2\text{P.}\\
 & & = \text{the area required.}
\end{array}$$

EXAMPLE 2.

The following field-notes are given to protract the survey and find the area.

		Ch.
1.	N. 15° 00′ E.	20
2.	N. 37° 30′ E.	10
3.	East	7.50
4.	S. 11° 00′ E.	12.50
5.	South	13.50
6.	West	10.
7.	S. 36° 30′ W.	10.
8.	N. 38° 15′ W.	8.50

Ans. 46 A. 2 R. 9 P.

CHAPTER IV.

LAYING OUT AND DIVIDING LAND.

PROBLEM I.

To lay out a given quantity of land in a square form.

RULE.

Reduce the given quantity to chains or perches, and extract the square root, which will be the length of a side, of the same denomination to which the given quantity is reduced.

EXAMPLES.

1. Required the side of a square that shall contain 9 A. 3 R. 28 P.

40)28 Per.
4)3.7R.
9.925 A.=99.25 ch.

Ch.
99.25(9.96 ch. the length of a side.
81
189)1825
1701
1986)12400
11916
484

2. Required the side of a square tract of land that shall contain 325 acres. *Ans.* 57 chains.

PROBLEM II.

To lay out a given quantity of land in a rectangular form, having one side given.

RULE.

Divide the given content by the length of the given side, the quotient will be the length of the required side.

EXAMPLES.

1. It is required to lay out 120 acres in a rectangular form, the length of one side being given, equal 100 perches.

```
      Acres.
        120
          4
        ———
        480
         40
       ————
1,00)192,00
       ————
        192 Per. the length of the other side.
```

2. The length of a rectangular piece of land is 8 chains; what must be its breadth, that the content may be 5 acres?

Ans. 6.25 chains.

PROBLEM III.

To lay out a given quantity of land in a rectangular form, having the length to the breadth, in a given ratio.

RULE.

As the less number of the given ratio,
Is to the greater;
So is the given area,
To a fourth term.*

The square root of this fourth term will be the length required. Having the length, the breadth may be found by the preceding problem. Or it may be found in the same manner as the length. Thus,

As the greater number of the given ratio,
Is to the less;
So is the given area,
To a fourth term.

The square root of this fourth term will be the breadth required.

EXAMPLES.

1. It is required to lay out 864 acres in a rectangular form, having the length to the breadth in the ratio of 5 to 3.

---

* **Demonstration.** Let ABCD, Fig. 85, be a rectangle, and ABFE and AHGD be squares on the greater and less sides respectively: then (1.6) AD : AE (AB) : : the rectangle AC : square AF. Also AB : AH (AD) : : the rectangle AC : square AG. Hence the truth of the rule is evident.

864 A=138240 P.

Sq. P.   Sq. P.
As 3 : 5 :: 138240 : 230400
$\sqrt{230400}=480$ Perches, the length required.

Sq. P.   Sq. P.
As 5 : 3 :: 138240 : 82944
$\sqrt{82944}=288$ Perches, the breadth required.

2. It is required to lay out 27 A. 3 R. 20 P. in a rectangular form, having the length to the breadth in the ratio of 9 to 7. *Ans.* Length 75.725 P. Breadth 58.897 P.

PROBLEM IV.

To lay out a given quantity of land in a rectangular form, having the length to exceed the breadth by a given difference.

RULE.

To the given area, add the square of half the given difference of the sides, and extract the square root of the sum; to this root, add half the given difference for the greater side, and subtract it therefrom for the less.*

---

* DEMONSTRATION. Let ABCD, Fig. 86, be a rectangle; in DC let DE be taken equal DA or BC, and let EC be bisected in F; then (6.2) $DF^2=DC\times DE+FC^2=DC\times AD+FC^2$=the rectangle AC+the square of half the difference of the sides DC, DA; also DF+FC=DC, the greater side, and DF−FC=DE or DA, the less side.

This problem may be neatly constructed thus: take EC equal the given difference of the sides and bisect it in F; make EG perpendicular to EC and equal to the square root of the given area, and with the centre F and radius FG describe the arc DG meeting CE produced in D: make DA perpendicular to DC and equal to DE, and complete the rectangle ABCD, which will be the one required. Since (47.1.) $FG^2=EG^2+EF^2$=the given area+the square of half the given difference of the sides, the truth of the construction is plain, from the preceding demonstration.

EXAMPLES.

1. It is required to lay out 47 A. 2 R. 16 P. in a rectangle, of which the length is to exceed the breadth by 80 perches.

2)80 P.	47 A. 2 R. 16 P.=7616 Per.
—	1600
40	——
40	$\sqrt{9216}=96$
——	half diff. add and subtract 40
1600	—
	length 136
	——
	breadth 56

2. It is required to lay out 114 A. 2 R. 33.4 P. in a rectangular form, having the length to exceed the breadth by 15.10 ch. *Ans.* Length 42.25 ch. Breadth 27.15 ch.

PROBLEM V.

To lay out a given quantity of land in the form of a triangle or parallelogram, one side and an adjacent angle being given.

RULE.

For a triangle.

As the rectangle of the given side and sine of the given angle,
Is to twice the given area;
So is radius,
To the other side, adjacent to the given angle.

Then having two sides and the included angle given, the other angles and side, if required, may be found by trig. case 3.

For a parallelogram.

As the rectangle of the given side and sine of the given angle,
Is to the given area;
So is radius,
To the other side, adjacent to the given angle.*

EXAMPLES.

1. Let AB, BC, *Fig.* 87, be two sides of a tract of land; the bearing of AB is S. 87½° W. dist. 16.25 ch. and the bearing of BC, N. 27½° E.; it is required to lay off 10 acres by a straight line AD, running from the point A, to the side BC.

Bearing of BA, N. 87½° E.
——— BC, N. 27½ E.

Angle B, 60°

As AB × sin. B {	AB 16.25 ch. - -	Ar. Co. 8.78915
	sin. B, 60° - -	——— 0.06247
:	twice the given area 200 sq. ch. - -	2.30103
: :	rad. - - - - - - - - - - - -	10.00000
:	BD 14.21 ch. - - - - - - - - -	1.15265

---

* DEMONSTRATION. It is demonstrated, prob. 3. chap. 3, Content of Land, that rad. : sin. B : : AB×BD : 2ABD (see Fig. 87); therefore (1.6 cor.) rad.×AB : sin. B×AB : : AB×BD : 2ABD, or (16.5) sin. B×AB : 2ABD : : rad.×AB : AB×BD : : rad. : BD. Since ABDF is equal to 2ABD, the truth of the rule for the parallelogram is evident.

This problem may be constructed as follows; take AB equal the given side and draw BC making the angle B equal to the given angle; make BE perpendicular to AB, and equal twice the given area of the triangle divided by the given side, or equal the given area of the parallelogram divided by the given side; and parallel to AB, draw EF cutting BC in D, and join DA; then will ABD be the triangle required; or complete the parallelogram ABDF, for the one required. The reason of the construction is plain.

2. Given the side AB, *Fig.* 15, of a parallelogram, equal 20 ch. and the angle A 63° 30′; required the side AC, that the content may be 21½ acres.

As AB×sin. A	AB 20 ch.	Ar. Co.	8.69897
	sin. A 63° 30′	———	0.04821
: the given area 215 sq. ch.			2.33244
: : rad.			10.00000
: AC 12.01 ch.			1.07962

3. Given one side of a triangle, equal 30 perches, an angle adjacent to this side 71° 15′, and the area 2 acres; required the other side adjacent to the given angle.

Ans. 22.53 perches.

4. Given one side of a parallelogram, equal to 32.26 ch., an angle adjacent to this side 83° 30′, and the area 74 acres; required the other side adjacent to the given angle. *Ans.* 23.09 ch.

PROBLEM VI.

The area and base of a triangle being given, to cut off a given part of the area by a line running from the angle opposite the base.

RULE.

As the given area of the triangle,
Is to the area of the part to be cut off;
So is the given base,
To the base corresponding to that area.*

---

* The truth of this rule is manifest from 1.6.

EXAMPLES.

1. Given the area of the triangle ABC, *Fig.* 88, equal 650 square perches, and the length of the base AB, 40 perches; it is required to cut off 290 perches towards the angle A, by a line running from the angle C to the base.

ABC. ADC. AB. AD.
As 650 : 290 : : 40 : 17.85 per.

2. In a triangle ABC, there are given the area 27 A. 1 R. 16 P. and the base AB 35.20 ch., to cut off 10 acres towards the angle B, by a line CD running from the angle C to the base: the part BD of the base is required.
Ans. 12.87 ch.

PROBLEM VII.

The area and two sides of a triangle being given, to cut off a triangle containing a given area, by a line running from a given point in one of the given sides, and falling on the other.

RULE.

As the given area of the triangle,
Is to the area of the part to be cut off;
So is the rectangle of the given sides,
To a fourth term.

Divide this fourth term by the distance of the given point from the angular point of the two given sides; the quotient will be the distance of the required point from the same angle.[*]

---

[*] Demonstration. From the demonstration to prob. 3, chap. 3, we have, Fig. 89. rad. : sin. A : : AB×AC : 2ABC, and rad. : sin. A : : AP×AG : 2APG; therefore (11 & 16.5) 2ABC : 2APG : : AB×AC : AP×AG, or (15.5) ABC : APG : : AB×AC : AP×AG; hence the truth of the rule is manifest.

EXAMPLES.

1. Given the area of the triangle ABC, *Fig.* 89, 5 acres; the side AB 50 perches, the side AC 40 perches, and the distance of a point P from the angle A, 36 perches; it is required to find a point G to which, if a line be drawn from the point P, it shall cut off a triangle APG containing 3 A. 0 R. 20 P.

As the triangle ABC 800 sq. p.	Ar. Co. 7.09691
: the triangle APG 500	2.69897
: : AB×AC { AB 50	1.69897
AC 40	1.60206
: AP×AG	3.09691
AP 36	log. 1.55630
AG 34.72 per.	1.54061

2. Given the area of a triangle ABC, 12 A. 1 R. 23 P. the side AB 20 ch., the side AC 16.25 ch., and the distance of a point P in the side AB, from the angle A 8.50 ch.; it is required to find the distance AG of a point G in the line AC, so that a line drawn from P to G may cut off a triangle APG containing 3 acres. *Ans.* 9.25 ch.

PROBLEM VIII.

The area and base of a triangle being given, to cut off a triangle containing a given area, by a line running parallel to one of the sides.

RULE.

As the given area of the triangle,
Is to the area of the triangle to be cut off;
So is the square of the given base,
To the square of the required base.

The square root of the result will be the base of the required triangle.*

EXAMPLES.

1. Given the area of the triangle ABC, *Fig.* 90, 500 square perches, and the base AB 40 perches; it is required to cut off 120 sq. per. towards the angle A, by a line DG running parallel to the side BC.

As the triangle ABC 500	- - - Ar. Co.	7.30103
: the triangle ADG 120	- - - - -	2.07918
: : AB^2	AB 40 - - - - -	1.60206
	AB 40 - - - - -	1.60206
: AD^2	- - - - - - - - - - -	2)2.58433
AD 19.6 per.	- - - - - - - -	1.29216

2. Given the area of a triangle ABC, 10 acres, and the base AB 25 ch., to find BD a part of the base, so that a line DG running from the point D, parallel to the side AC, may cut off a triangle BDG containing 4½ acres.

Ans. BD=16.77 ch.†

---

* The truth of this rule is manifest from 19.6.

This problem may be neatly *constructed* as follows: Let ABC, Fig. 90, be the given triangle, and AB the given base; on AB describe the semicircle AEB, and take AF to AB in the ratio of the part to be cut off, to the whole triangle; draw FE perpendicular to AB, meeting the semicircle in E, join AE, and make AD equal to AE; from D draw DG parallel to BC and the thing is done. For, join EB, and we have, by similar triangles, AB : AE : : AE : AF; therefore (20.6 cor. 2.) AB : AF : : AB^2 : AE^2 (AD^2) : : [19.6] ABC : ADG.

† If it be required to produce two sides of a given triangle so far that the triangle formed by these sides produced, and a line drawn between them parallel to the third side, may contain a given area, it may be done by the above rule. Thus, Fig. 90, ADG : ABC : : AD^2 : AB^2.

PROBLEM IX.

The bearings of two adjacent sides AD, AE, *Fig.* 91, *of a tract of land being given, to cut off a triangle* ABC *containing a given area by a line* BC *running a given course.*

RULE.

From the given bearings of the lines, find the angles A, B, and C; then,

As the rectangle of the sines of the angles A and B,
Is to the rectangle of radius and sine of the angle C;
So is twice the given area,
To the square of the side AB.*

In like manner the other sides may be found; or having found one side, the others may be found by trig. case 1.

EXAMPLES.

1. Let the bearing of AD, *Fig.* 91, be N. 87° 30′ E. and of AE, N. 27° 30′ E.; it is required to cut off 10 acres by a line BC running N. 38° W.

---

* The truth of this rule is evident from the demonstration to prob. 4, chap. 3.

Construction. Draw AD, AE, (Fig. 92,) according to the given bearings, and in AD take AF equal the square root of the given area, and on it describe the square AFGH; make IE=AI, and draw ED, according to the reverse bearing of the division line BC, meeting AD in D; on AD describe a semicircle, and produce GF to meet it in K, join AK and make AB equal to it; draw BC parallel to DE, and ABC will be the triangle required. For join IF, EF and KD; then (31.3, and cor. 8.6) AD : AK (AB) : : AK (AB) : AF; or (cor. 19.6) AD : AF : : ADE : ABC; but (1.6) AD : AF : : ADE : AFE; therefore (11.5) ADE : ABC : : ADE : AFE, and consequently (9.5) ABC=AFE; but because AI=IE, AFE=2AFI=(41.1) AFGH; therefore ABC=AFGH=the given area of the triangle.

AD, N. 87° 30′ E.	BA, S. 87° 30′ W.	CA, S. 27° 30′ W.
AE, N. 27 30 E.	BC, N. 38 00 W.	CB, S. 38 00 E.
Angle A, 60 00	125 30	Angle C, 65 30
	180 00	
	Angle B, 54 30	

As sin. A × sin. B,	A 60° 00′	Ar. Co.	0.06247
	B 54 30		0.08931
: rad. × sin. C,	C 65 30		9.95902
	rad.		10.00000
: : twice the given area, 200 sq. ch.			2.30103
: AB^2			2)2.41183
AB 16.07			1.20591

2. Given the bearing of one side of a tract of land, S. 53° 15′ E., and the bearing of an adjacent side taken at the same angle, N. 55° 00′ E., to cut off 4 acres by a line running N. 4° 00′ W.; required the distance on the first side. *Ans.* 9.76 ch.

PROBLEM X.

The bearings of three adjacent sides, EA, AB, BF, *Fig.* 93 *or* 94, *of a tract of land, and the length of the middle side* AB, *being given, to cut off a trapezoid* ABCD, *containing a given area, by a line* DC, *parallel to* AB.

RULE.

From the given bearings find the angles A and B; add these together, and take the difference between their sum and 180°, and call it P. Then,

As the product of the sines of A and B,
Is to the product of radius and sine of P;

So is twice the area to be cut off,
To a fourth term.

When the sum of the angles A and B is greater than 180° add this fourth term to AB^2; but when the sum of these angles is less than 180°, take the difference between this fourth term and AB^2. The square root of the result will be DC. Then,

As the sine of P,
Is to the sine of B,
So is the difference between DC and AB,
To AD.*

---

* DEMONSTRATION. Produce EA and FB, Fig. 95, to meet in P. Then (19.6) $PDC : PAB :: CD^2 : AB^2$, or (17.5) $ABCD : PAB :: CD^2-AB^2 : AB^2$, or (A.5) $PAB : ABCD :: AB^2 : CD^2-AB^2$, or (15.16.5) $2PAB : AB^2 :: 2ABCD : CD^2-AB^2$. But by the demonstration to prob. 4, chap. 3, $2PAB : AB^2 :: \sin. A\times\sin. B : \mathrm{rad.}\times\sin. P$. Consequently, (11.5)

$$\sin. A\times\sin. B : \mathrm{rad.}\times\sin. P :: 2ABCD : CD^2-AB^2.$$

Now it is plain that AB^2, added to this fourth term, gives CD^2. A similar demonstration applies when the sum of the angles A and B is less than 180°, as in Fig. 94. The latter part of the rule does not require demonstration.

Construction. Draw AI, Fig. 93, perpendicular to AB, and make it equal to the quotient of twice the given area divided by AB. From I, draw IH parallel to AB meeting AE and BF, in G and H, and on GH, describe the semicircle GMH. From A, draw AL parallel to BF; and make LM perpendicular to GH. With the distance HM and centre H, describe the arc MN; and from N, draw ND parallel to AL. Lastly, draw DC parallel to AB, and it will be the division line required. For join BD, BG, and CG, Fig. 95. Then by similar triangles $PG : PD :: GH : DC :: GH : HM :: HM : HL :: DC : AB :: PC : PB$. Hence (3.6) CG is parallel to BD; and consequently the triangle BDC is equal to BGD. To each of these, add ABD. Then we have $ABCD=ABG$. But it is plain from the construction that ABG is equal to the given area. Hence ABCD is equal to the given area.

When the sum of the angles A and B is *less* than 180°, as in Fig. 94,

EXAMPLES.

1. Given the bearing of EA, Fig. 93, West, AB, N. 10° E. dist. 15 ch.; and BF, N. 58° 30′ E. to cut off 10 acres by a line CD, running parallel to AB. Required the length of the division line and the distance AD.

AE, N. 90° E.	BF, N. 58° 30′ E.	A, 80° 0′
AB, N. 10 E.	BA, S. 10 0 W.	B, 131 30
A = 80°	48° 30	211 30
	180 0	180 0
	B=131 30	P=31° 30′

As sin. A × sin. B,	A, 80° 00′	Ar. Co.	0.00665
	B, 131 30	———	0.12554
: Rad. × sin. P,	Rad.	- - - - - - -	10.00000
	P, 31 30	- - - -	9.71809
: : twice the given area 200 sq. ch.		- - -	2.30103
: fourth term	141.68 - -	- - -	2.15131

AB^2=225.

DC=$\sqrt{366.68}$=19.15 ch.

As sin. P,	31° 30′	- - Ar. Co.	0.28191
: sin. B,	131 30	- - - - - -	9.87446
: : DC—AB,	4.15	- - - - - - -	0.61805
: AD	5.95	- - - - - - -	0.77442

---

the semicircle must be described on AB; the point L must be determined by drawing GL parallel to FB: and the arc MN must be described with the radius BM and centre B. The other parts of the construction are the same as before.

2. Given the bearings of three adjacent sides of a tract of land and the length of the middle one as follow; 1st. N. 20° W.; 2d. N. 60° 30′ E. dist. 6 ch.; 3d. S. 61° 30′ E.; to cut off a lot containing 2¼ acres, by a line parallel to the 2d side. Required the length of the division line and the distance on the 1st. side.

Ans. Division line 8.70 ch.; distance on 1st. side 3.45 ch.

3. Given as follow; 1st. side N. 31° 15′ W.; 2d. N. 58° 45′ E. dist. 13.50 ch.; 3d. S. 14° 45′ E.; to cut off 8 acres by a line parallel to the 2d. side. The length of the division line and the distance on the 1st. side are required. *Ans.* Division line 11.61 ch.; distance on the 1st. side 6.38 ch.

PROBLEM XI.

The bearings of three adjacent sides EA, AB, BF, *Fig.* 96, *of a tract of land, and the length of the middle side* AB *being given, to cut off a trapezium,* ABCD, *containing a given area, by a line* CD, *running a given course.*

RULE.

Draw AS parallel to BF, meeting CD or CD produced, in S. From the given bearings, find the interior angles A, B, C, and D; add A and B together, and take the difference between their sum and 180°, and call it P. Then,

As the product of the sines of C and D,
Is to the product of radius and sine of P;
So is twice the area to be cut off,
To a fourth term.

Also, as the product of the sines of C and D,
Is to the product of the sines of A and B;
So is AB^2,
To a fourth term.

When the sum of the angles A and B, is greater than 180°, add these two fourth terms together; but when the sum of these angles is less than 180°, take the difference of the fourth terms. The square root of the result will be CD. Then,

As, sin. C : sin. B : : AB : CS.

The difference between CD and CS, gives DS. Then,

As, sin. P : sin C : : DS : AD.*

---

* Demonstration. Produce EA and FB, Fig. 97, to meet in P; draw AR and BU, each parallel to CD, and let VW, also parallel to CD, make the triangle PVW equal to PAB. Then (15.6) PA : PV : : PW : PB; but (4.6) PA : PV : : AR : VW, and PW : PB : : VW : BU. Therefore (11.5) AR : VW : : VW : BU, and hence (17.6) $AR \times BU = VW^2$. But by trigonometry,

As sin. ARB (sin. C) : sin. B : : AB : AR,
sin. AUB (sin. D) : sin A : : AB : BU.

Hence (23.6.) As sin. C×sin. D : sin. A×sin. B : : $AB^2 : AR \times BU$
Or, sin. C×sin. D : sin A×sin. B : : $AB^2 : VW^2$.

And by the demonstration to the rule in the last problem, we have
sin. C×sin. D : rad.×sin. P : : 2VWCD (2ABCD) : $CD^2 - VW^2$.

The sum of these fourth terms gives CD^2. The demonstration is similar, when the sum of the angles A and B is less than 180°.

Construction. From B, *Fig.* 96, draw BU according to the reverse bearing of the division line DC, meeting EA or EA produced in U. Make AI perpendicular to AB, and equal to the quotient of twice the given area, divided by AB. Draw IG parallel to AB; GH parallel to BU; and UL parallel to BF. On GH, describe the semicircle GMH, and make LM perpendicular to GH; with the radius HM and centre H, describe the arc MN; and from N, draw ND parallel to UL. From D, draw the division line DC parallel to BU.

EXAMPLES.

1. Let the bearings of EA, Fig. 96, be N. 80° 30′ W.; AB, North, dist. 12 ch.: and BF, N. 58° E.; it is required to cut off 10 acres by a line DC, running N. 14° 30′ W.

AE, S. 80° 30′ E.	BF, N. 58° E.	CB, S. 58° 00′ W
AB, N. 0 00 E.	BA, S. 0 E.	CD, S. 14 30 E
80 30	58	C=72° 30′
180 0	180	
A= 99° 30′	B=122	

DA, N. 80° 30′ W.	A = 99° 30′
DC, N. 14 30 W.	B=122 00
D=66° 00′	221 30
	180 00
	P=41 30

As sin. C × sin. D	C, 72° 30′ - - -	Ar. Co.	0.02058
	D, 66 00 - - -	———	0.03927
: rad. × sin. P,	rad. - - - - - - -		10.00000
	P, 41 30 - - - - -		9.82126
: : twice the given area 200 sq. ch. - - -			2.30103
. fourth term 152.1 - - - - - - - -			2.18214

When the sum of the angles A and B is less than 180°, the semicircle must be described on BU; the point L must be determined by drawing GL parallel to BF, and the arc MN must be described with the radius BM and centre B.

The demonstration is exactly the same as that for the construction of the last problem.

As sin. C×sin. D,	C 72° 30′	Ar. Co.	0.02058
	D 66 00	———	0.03927
: sin. A×sin. B,	A 99 30		9.99400
	B 122 00		9.92842
: : AB²	AB 12		1.07918
	AB 12		1.07918
: fourth term	138.24		2.14063
fourth term	152.10		

$$DC = \sqrt{290.34} = 17.04$$

As sin. C 72° 30′	Ar. Co.	0.02058
: sin. B 122 00		9.92842
: : AB 12		1.07298
: CS 10.67		1.02818
DC 17.04		
DS 6.37		

As sin. P 41° 30′	Ar. Co.	0.17874
: sin. C 72 30		9.97942
: : DS 6.37		0.80414
: AD 9.17		0.96230

2. Given the bearings of three adjacent sides of a tract of land and the length of the middle one as follow: 1st. N. 31° 15′ W.; 2d. N. 58° 45′ E. dist. 13.50 ch.; 3d. S. 14° 45′ E.; to cut off 8 acres by a line from the 1st. side to the 3d. running S. 87° 30′ E.; required the length of the division line and the distance on the 1st side.

Ans. Division line 12.76 ch.; distance 1st. side 2.69 ch.

3. Given as follow; 1st side, N. 74° 45′ W.; 2d. N. 37° E. dist. 17.24 ch.; 3d. N. 84° E.; to cut off a field containing 20 acres, by a line from the 1st. side to the 3d

running N. 20° E. The length of the division line and the distance on the 1st. side are required.

Ans. Division line 19.68 ch.; distance on 1st. side 14.01 ch.

PROBLEM XII.

The bearings of several adjacent sides, EA, AV, VW, WX, XB, BF, *Fig.* 98, *of a tract of land, and the distance of each, except the first and last, being given, to cut off a given area, by a line* DC, *running a given course.*

RULE.

Join AB and calculate the area of AVWXBA, and the bearing and distance of AB. Subtract the area of AVWXBA from the area to be cut off, the remainder will be the area of ABCD. Then with the bearings of EA, AB, BF, DC, the distance AB, and the area of ABCD, proceed as in the last problem.

EXAMPLES.

1. Let the bearing of EA, Fig. 98, be N. 48° 30′ W. AV, S. 78° W. dist. 8 ch.; VW, N. 26° 30′ W. dist. 11.08 ch.; WX, N. 38° 30′ E. dist. 12.82 ch.; XB, S. 64° E. dist. 10.86 ch.; and BF, S. 86° E. It is required to cut off 30 acres by a line DC, running N. 32° 15′ E.

Stat.	Bearing.	Dist.	N.	S.	E.	W.	E. D.D.	W.D.D.	Multipliers.	N. Ar.	S. Areas.
AV	S. 78° W	8.00		1.66		7.83		12.79	0.00 E		
VW	N. 26½ W	11.08	9.91			4.95		12.78	12.78 W		126.6498
WX	N. 38½ E	12.82	10.03		7.98		3.03		9.75 W		97.7925
XB	S. 64 E.	10.86		4.76	9.76		17.74		7.99 E		38.0324
BA				(13.52)		(4.96)	4.80		12.79 E		172.9208
			19.94	19.94	17.74	17.74	25.57	25.57			435.3955
											Sq. ch. 217.69775

	Sq. ch.
Area to be cut off	300.
Area of AVWXBA	217.69775
Area of ABCD	82.30225

As diff. of lat. of BA, 13.52 S.	Ar. Co.	8.86902
: dep. do. 4.96 W.		0.69548
: : rad.		10.00000
: tang of bearing of BA, S. 20° 9′ W.		9.56450

As rad.	Ar. Co.	0.00000
: sec. of bearing 20° 9′		10.02743
: : diff. of lat. 13.52		1.13098
: BA 14.40		1.15841

The angles, found from the bearings, are A=111° 21′, B=106° 9′, C=61° 45′, D=80° 45′ and P=37° 30′.

As sin. C×sin. D	C, 61° 45′	Ar. Co.	0.05508
	D, 80 45	———	0.00568
: rad.×sin. P,	rad.		10.00000
	P, 37 30		9.78445
: : twice the area ABCD 164.6 sq. ch.			2.21643
: fourth term 115.25			2.06164

As sin. C×sin. D,	C, 61° 45′	Ar. Co.	0.05508
	D, 80 45	———	0.00568
: sin. A×sin. B,	A, 111 21		9.96912
	B, 106 9		9.98251
: : AB^2	AB, 14.40		1.15836
	AB, 14.40		1.15836
: fourth term 213.36			2.32911

do. 165.25

$DC = \sqrt{328.61} = 18.13$

As sin. C, 61° 45′ Ar. Co. 0.05508
: sin. B, 106 9 - - - - - - - 9.98251
:: AB, 14.40 - - - - - - - - 1.15836

: CS, 15.70 - - - - - - - - - 1.19595

As sin. P, 37° 30′ Ar. Co. 0.21555
: sin. C, 61 45 - - - - - - - 9.94492
:: DS, 2.43 - - - - - - - - - 0.38561

: AD, 3.52 - - - - - - - - - 0.54608

2. Given as follow; 1st. side, N. 62° 15′ W.; 2d. N. 19° E. dist. 18 ch.; 3d. S. 77° E. dist. 15.25 ch.; 4th. S. 27° E.; to cut off 35 acres by a line, from the first side to the last, running N. 82° 30′ E. Required the length of the division line, and the distance on the first side.

Ans. Division line 22.98 ch.; distance on 1st. side 5.14 ch.

PROBLEM XIII.

The bearings of several adjacent sides, AB, BC, CD, DE, *Fig.* 99, *of a tract of land, and the distance of each, except the last, being given, to cut off a given area by a line* AH *running from the angle* A, *and falling on the side* DE.

RULE.

By Prob. 9, chap. 1, change the bearings of all the given sides, so as to make the side, on which the division line is to fall, a meridian.

With the given distances and *changed* bearings, find the corresponding differences of latitude and departures; add together the numbers in each departure column, and take the difference of their sums, which will be the departure of the division line, and must be placed in the proper column, opposite said line. Then having all the departures, find the double departures, as in Prob. 11. of the last chapter. Find also the multipliers, beginning with the one to correspond with the division line, and assuming it 0; multiply the known differences of latitude by their corresponding multipliers, and place the products in the proper columns of north and south areas.

Add together the products in each of the columns of areas, and subtract the less sum from the greater; take the difference between the remainder and double the area to be cut off, and divide it by the multiplier corresponding to the side on which the division line is to fall; the quotient will be the difference of latitude of this side, which place against it, in the column of north or south latitude, according as its changed bearing is north or south. Then add together the numbers in each latitude column, and take the difference of their sums, which will be the difference of latitude of the division line, of the *same* name with the *less* sum.

With the difference of latitude and the departure of the division line, find, by Prob. 10, chap. 1, its changed bearing and its distance. Then find the true bearing by note to the rule in Prob. 9, chap. 1.*

EXAMPLES.

1. Let the bearing of AB be N. 62¼° W. 14.75 ch.; BC, N. 19° E. 27 ch.; CD, S. 77° E. 22.75 ch.; and DE, S. 27° E.; it is required to cut off 70 acres by a line AH, running from the angle A and falling on the side DE.

---

* The reason of this rule is sufficiently obvious without a demonstration.

Sta.	Bearings.	Changed Bearings.	Dist.	N.	S.	E.	W.	E.D.D.	W.D.D.	Multipliers.	N. Ar.	S. Areas.
AB	N. 62¼° W.	N. 35¼° W.	14.75	12.04			8.51		36.84	36.84 W		443.5536
BC	N. 19 E.	N. 46 E.	27.00	18.76		19.42		10.91		25.93 W		486.4468
CD	S. 77 E.	S. 50 E.	22.75		14.62	17.42		36.84		10.91 E		159.5042
DH	S. 27 E.	South			(10.96)			17.42		28.33 E		
HA					(5.22)		(28.33)		28.33	0.00 E		
				30.80	30.80	36.84	36.84	65.17	65.17			1089.5046

1400.0000 Lat. of DH

28.33)310.4954(10.96
2833
27195
25497
16984
16998

As diff. lat. of HA, 5.22 S. - - Ar. Co. 9.28233
. dep. do. 28.33 W. - - - - - - 1.45225
· : rad. - - - - - - - - - - - - - - 10.00000

: tang. changed bear. of HA, S. 79° 34′ W. 1073458
Subtract 27 00

True bearing of HA, S. 52 34 W.

As rad. - - - - - - - - - - - Ar. Co.	0.00000
: sec. changed bearing of HA, 79° 34′	10.74210
: : diff. lat. 5.22 - - - - - - - - -	0.71767
: dist. AH, 28.83 - - - - - - - -	1.45977

Hence AH, bears N. 52° 34′ E. dist. 28.83 ch.

2. Given as follow: 1st. side S. 78° W. 8 ch.; 2d. N. 26½° W. 11.08 ch.; 3d. N. 38½° E. 12.82 ch.; 4th. S. 64° E. 10.86 ch.; 5th. S. 23¼°E.; to cut off 25 acres by a line running from the place of beginning, and falling on the 5th. side; required its bearing and distance.

Ans. N. 45° 1′ E. dist. 10.67 ch.

PROBLEM XIV.

The sides AB, BC, CA, *Fig.* 100, *of a triangular piece of ground being given, to divide it into two parts having a given ratio, by a line* FE, *running parallel to one of the sides as* BC.

RULE.

As the sum of the numbers expressing the ratio of the parts,
Is to that number of the ratio which corresponds to the part to be adjacent to A;
So is the square BC,
To the square of FE.

Then, As BC : AB : : FE : AF.*

---

* DEMONSTRATION. Let m to n be the ratio of the part AFE to the part FECB; then (18.5) $m+n : m :: ABC : ADE : (19.6)\ BC^2 : FE^2$.

Construction. On AB describe the semicircle AMB, and by Prob. 17, Page 34, divide AB in K, so that AK may be to KB in the given ratio of the part AFE to the part FECB; draw KM perpendicular to AB, meeting the

EXAMPLES.

1. Let AB be 21.26 ch.; BC, 12.76 ch.; and AC, 19.30 ch.; it is required to divide the triangle by the line FE, parallel to BC, so that the part AFE may be to the part FECB as 2 to 3.

As 5 : 2 : : 12.76^2 : FE^2=65.12704.
FE= $\sqrt{65.12704}$=8.07
As 12.76 : 21.26 : : 8.07 : AF=13.45.

2. The three sides of a triangular piece of land, taken in order, measure 15, 10, and 13 chains respectively; it is required to divide it into two equal parts by a line parallel to the second side. What will be the length of the division line and its distance from the place of beginning, measured on the first side?

Ans. Division line 7.07 ch.; dist. on 1st. side 10.61 ch.

PROBLEM XV.

The bearings and distances of the sides AB, BC, CA, *Fig.* 101, *of a triangular piece of ground being given, to divide it into two parts having a given ratio, by a line* FE, *running a given course.*

RULE.

As the product of the sines of F and E,
Is to the product of the sines of B and C;

---

semicircle in M, and with the radius AM and centre A, describe the arc MF. From F, draw the division line FE parallel to BC. Since, (35.3, and cor. 8.6) AB : AM (AF) : : AM (AF) : AK, we have (20.6 cor. 2) AB : AK : : AB^2 : AF^2 : : ABC : AFE. Hence the truth of the construction is evident.

So is the square of BC,
To a fourth term.

Multiply this fourth term by that number of the ratio which corresponds to the part to be adjacent to the angle A, and divide the product by the sum of the numbers expressing the ratio. The square root of the result will be FE. Then,

As sin. A : sin. E : : FE : AF.*

EXAMPLES.

1. Let the bearing of AB, be S. 82¼° E. dist. 14.17 ch.; BC, N. 18¾° W. 8.51 ch.; and CA, S. 61½° W. dist. 12.87 ch.; it is required to divide the triangle by the line FE, running N. 14¾° E. so that the part AFE may be to the part FECB in the ratio of 2 : 3.

---

* DEMONSTRATION. Draw CG and BR, Fig. 102, each parallel to EF; and let VW, also parallel to EF, make the triangle AVW equal to ABC. Then (15.6) AB : AV : : AW : AC; but (4.6) AB : AV : : BR : VW, and AW : AC : : VW : GC. Therefore BR : VW : : VW : GC; and hence (17.6) BR×GC=VW^2. But by trigonometry,

As sin. R (sin. E) : sin. C : : BC : BR,
sin. G. (sin. F) : sin B : : BC : GC.

Hence (23.6) sin. E×sin. F : sin. B×sin. C : : BC^2 : BR×GC : : BC^2 · VW^2.

Also, $m+n : m$: : ABC : AFE : : AVW : AFE : : (19.6) VW^2 : FE^2.

Construction. From C, *Fig.* 101, draw CG according to the reverse bearing of FE, and on AG describe the semicircle AMG. By prob. 17, page 34, divide AB in K, so that AK may be to KB in the given ratio of the part AFE to the part FECB. Draw KM perpendicular to AB, and with the radius AM and centre A, describe the arc MF. From F, and parallel to GC, draw FE the required division line. For join KC, *Fig.* 102; then (1.6) KC divides the triangle in the given ratio. Now AC : AE : : AG : AF (AM) : : (cor. 8.6) AM (AF) : AK; therefore (11.5) AC : AE : : AF : AK, and hence (15.6) the triangle AFE is equal to AKC. Consequently FE divides the triangle in the given ratio.

Angle A=36¼°, B=63½°, C=80¼°, E=46¾° and F=83°.

As sin. E×sin. F,	E, 46° 45′	Ar. Co.	0.13765
	F, 83 00	———	0.00325
: sin. B×sin. C,	B, 63 30	- - - - -	9.95179
	C, 80 15	- - - - -	9.99368
: : BC²,	BC, 8.51	- - - - -	0.92993
	BC, 8.51	- - - - -	0.92993
: fourth term	88.35	- - - - - - - -	1.94623

88.35
2
———
5)176.70
———

FE= $\sqrt{35.34}$=5.95

As sin. A,	36° 15′	- - - - - - Ar. Co.	0.22819
: sin. E,	46 45	- - - - - - - - - -	9.86235
: : FE,	5.95	- - - - - - - - - - -	0.77379
: AF,	7.32	- - - - - - - - - - -	0.86433

2. The bearings and distances of a triangular piece of land ABC are, AB, S. 69° E. 21.40 ch.; BC, N. 31½ E. 18.66 ch.; and CA, S. 74½ W. 30.85 ch.; and it is required to divide it by a line FE, running due north, so that the part AEF, may be to the part FECB, as 4 to 5. What will be the length of the division line FE, and the distance AF? *Ans.* FE 10.74, and AF 17.40.

PROBLEM XVI.

The bearings and distances of the sides AB, BC, CD, DA, *fig.* 103, *of a trapezoidal tract of land being given, to divide it into two parts having a given ratio, by a line* FE, *running parallel to the parallel sides* AB, CD.

RULE.

Multiply the square of AB, by that number of the ratio which corresponds to the part, to be adjacent to CD, and the square of CD, by the other number of the ratio. Add the two products together, and divide the sum by the sum of the numbers expressing the ratio. The square root of the quotient will give FE. Then,

As DC—AB : FE—AB : : AD : AF.*

EXAMPLES.

1. Let the bearing of AB be N. 14° E. dist. 10 ch. BC, N. 55½° E. dist. 18.67 ch.; CD, S. 14° W. dist. 20.98 ch.; and DA, W. 12.70 ch.; it is required to divide the trapezoid into two parts by a line FE, parallel to AB or DC,

---

* DEMONSTRATION. Produce DA and CB, Fig. 104, to meet in P. Then (19.6) PDC : PAB : : $CD^2 : AB^2$, or (17.5) ABCD : : PAB : : $CD^2—AB^2 : AB^2$, or (16.5) ABCD : $CD^2—AB^2$: : PAB : AB^2. In like manner ABEF : $FE^2—AB^2$: : PAB : AB^2. Hence (11.5) ABCD : $CD^2—AB^2$: : ABEF : $FE^2—AB^2$, or (16.5) ABCD : ABEF : : $CD^2—AB^2 : FE^2—AB^2$. Therefore $m+n : m$: : $CD^2—AB^2 : FE^2—AB^2$, or multiplying extremes and means, $\overline{m+n}\ FE^2—\overline{m+n}.\ AB^2=m.\ CD^2—m.\ AB^2$. But $(m+n.)\ AB^2=m.\ AB^2+n.\ AB^2$. Therefore, adding equals to equals, we have $\overline{m+n.}\ FE^2=m.\ CD^2+n.\ AB^2$. Hence the truth of the rule is evident.

Construction. Join CA, *Fig.* 103, and parallel to it, draw BH, meeting DA produced in H. Divide (prob. 17, page 34) HD in K so that HK may be to KD in the given ratio of ABEF to FECD, and draw KL parallel to BC. On CD, describe the semicircle CMD, and draw LM perpendicular to CD. With the radius CM and centre C, describe the arc MN, and from N draw NF parallel to KL. From F, draw the division line FE parallel to AB or CD. For join KC, Fig. 104, and draw KU parallel to AB. Then since BH is parallel to AC, the triangle AHC is equal to ABC; and adding ADC to each, we have CHD=ABCD. Now (4.6) PC : PE : : CD : FE (CM) : : (cor. 8.6) CM (EF) : CL (UK) : : PF : PK. Therefore (11.5) PC : PE : : PF : PK and hence (15.6) the triangle PEF is equal to PCK. Consequently CKD= FECD. But it has been proved that CHD=ABCD; hence taking equals from equals we have HCK=ABEF. But (1.6) HCK : CKD : : HK : KD : : *m* : *n*. Therefore ABEF : FECD : : *m* : *n*.

so that the part ABEF may be to the part FECD as 3 to 2.

$$
\begin{array}{r}
2.\ AB^2 = 200. \\
3.\ CD^2 = 1320.4812 \\
\hline
5)1520.4812 \\
\hline
\end{array}
$$

$$FE = \sqrt{304.0962} = 17.44$$

As 10.98 : 7.44 : : 12.70 : AF=8.61

2. The boundaries of a trapezoidal field ABCD are given as follow; viz. AB, N. 80° W. 60 per.; BC, N. 39½° W. 45.5 per.; CD, S. 80° E. 89.4 per.; and DA, South, 30 per.; and it is required to divide it into two equal parts by a line FE parallel to AB or CD. What will be the length of the division line FE, and the distance AF?

Ans. FE 76.13 per., and AF 16.46 per.

PROBLEM XVII.

The bearings and distances of the sides AB, BC, CD, DA, *Fig.* 105, *of any quadrilateral tract of land being given, to divide it into two parts having a given ratio, by a line* FE, *running parallel to one of the sides as* AB *or* CD.

RULE.

Call the side to which the division line is to be parallel, the *parallel* side; and the one opposite to this, the *opposite* side. From the bearings, find the angles. Take the difference between the sum of the angles adjacent to the parallel side and 180°, and call it P. Then,

As the product of the sines of the angles adjacent to the parallel side,
Is to the product of the sines of the angles adjacent to the opposite side:
So is the square of the opposite side,
To a fourth term.

Multiply this fourth term by that number of the ratio which corresponds to the part to be adjacent to the parallel side, and to the product add the product of the square of the parallel side by the other number of the ratio; and divide the sum by the sum of the numbers expressing the ratio. The square root of the quotient will be the length of the division line FE. Then,

As the sine of P,
Is to the sine of E;
So is the difference between FE and the parallel side,
To the distance of F from the adjacent end of the parallel side.*

---

* DEMONSTRATION. Produce DA and CB, *Fig.* 106, to meet in P. Draw DR and CG each parallel to AB; and let VW, also parallel to AB, make the triangle PVW equal to PCD. Then (15.6) PD : PV : : PW : PC. But (4.6) PD : PV : : DR : VW, and PW : PC : : VW : CG. Therefore (11.5) DR : VW : : VW : CG; and hence (17.6) $DR \times CG = VW^2$. But by trigonometry,

As sin. CRD (sin. B) : sin. C : : CD : DR.
sin. CGD (sin. A) : sin D : : CD : CG.
Hence (23.6.) sin. A × sin. B : sin. C × sin. D : : CD^2 : DR × CG.
Or, sin. A × sin. B : sin C × sin. D · : DC^2 . VW^2.

But by the demonstration to the rule in the last problem, we have

$$\overline{m+n}.\ FE^2 = m.\ VW^2 + n.\ AB^2.$$

Hence the truth of the rule is evident.

Construction. From C, *Fig.* 105, draw CG parallel to AB, and on it describe the semicircle CMG.

EXAMPLES.

1. Let the bearing of AB be North, 12 ch.; BC, N. 56½° E. 20.78 ch.; CD, S. 33½° E. 22.21 ch.; and DA, S. 80½° W. 30 ch.; it is required to divide the tract into two parts by a line FE, parallel to AB, so that the part ABEF may be to the part FECD as 3 to 5.

Angle A=80½°, B=123½°, C=90°, D=66°, and P=24°.

As sin. A×sin. B,	A, 80° 30′	Ar. Co.	0.00600
	B, 123 30	———	0.07889
: sin. C×sin. D,	C, 90 00		10.00000
	D, 66.00		9.96073
: : CD²	CD, 22.21		1.34655
	CD, 22.21		1.34655
: fourth term	547.92		2.73872

547.92
3
1643.76
5AB²=720.00
8)2363.76

FE=$\sqrt{295.47}$=17.19

As sin. P, 24° 00′	Ar. Co.	0.39069
: sin. E, 123 30		9.92111
: : FE−AB, 5.19		0.71517
: AF, 10.64		1.02697

Join CA, and draw BH parallel to it meeting DA produced in H. Divide HD in K, so that HK may be to KD in the given ratio of the part ABEF to FECD. Draw KL parallel to BC and LM perpendicular to CG. With the radius CM and centre C, describe the arc MN. Draw NF parallel to KL and FE parallel to AB. Then will FE be the division line. When the division line is to be parallel to CD, the semicircle must be described on CD; and the line CG need not be drawn. The demonstration of the construction is the same as for the last problem.

2. The boundaries of a field ABCD are given as follow: viz. AB, S. 10½° W. 7.20 ch.; BC, S. 67° W. 12.47 ch.; CD, N. 23° W. 13.33 ch.; and DA, S. 89° E. 18 ch.; and it is to be divided into two parts by a line FE, parallel to the side AB, so that the part ABEF may be to the part FECD, as 3 to 4. Required the length of the division line FE, and the distance AF.

Ans. FE 10.69 ch.; and AF 7.15 ch.

3. Given the boundaries of a field the same as in the preceding example, to divide it into two parts by a line FE, parallel to the side CD, so that the part ABEF may be to the part FECD, as 3 to 4. Required FE and AF.

Ans. FE 10.14, and AF 10.16.

PROBLEM XVIII.

The bearings and distances of the sides AB, BC, CD, DA, *Fig.* 107, *of any quadrilateral tract of land, being given, to divide it into two parts having a given ratio by a line* FE, *running a given course from some point in* AD *to another in* BC.

RULE.

From A, draw AS parallel to BC, meeting FE in S. From the bearings find the angles A, B, C, D, E, and F.* Take the difference between the sum of the angles A and B, and 180° and call it P. Then,

As the product of the sines of the angles E and F,
: the product of the sines of the angles A and B,
: : the square of AB,
: a fourth term.

Also, As the product of the sines of the angles E and F,
: the product of the sines of the angles C and D,

---

* It is immaterial whether it is the angle BEF or CEF, that is found, also whether, AFE or DFE.

: : the square of CD,
: to a fourth term.

Multiply this latter fourth term by that number of the ratio which corresponds to the part to be adjacent to AB, and the other fourth term by the other number of the ratio; add the two products together, and divide the sum by the sum of the numbers expressing the ratio. The square root of the quotient will give the length of the division line FE. Then,

As sin. E. : sin. B : : AB : ES.

The difference between FE and ES, gives FS. Then,

As sin. P. : sin. E : : FS : AF.*

EXAMPLES.

1. Let the bearing of AB be North, dist. 12 ch.; BC N. 56½° E. 20.78 ch.; CD, S. 33½° E. 22.21 ch.; and DA, S. 80½° W. 30 ch.; it is required to divide the tract into two parts by a line FE, running N. 20° W. so that the part ABEF may be to the part FECD as 3 to 5.

Angle A=80½°, B=123½°, C=90°, D=66°, E=76½°, F=79½° and P=24°.

As sin. E×sin. F,	E, 76° 30′	Ar. Co.	0.01217
	F, 79 30	———	0.00733
. sin. A×sin. B,	A, 80 30	- - - - -	9.99400
	B, 123 30	- - - - -	9.92111
: : AB²	AB, 12	- - - - -	1.07918
	AB, 12	- - - - -	1.07918
: fourth term	123.87	- - - - - - -	2.09297
	5		
	619.35		

---

* The truth of this rule is evident from the demonstration to the rule in the last problem.

Construction. Draw CG according to the reverse bearing of FE, and then proceed with the construction exactly as in the last problem.

As sin. E×sin. F,	E,	76° 30′	Ar. Co.	0.01217
	F,	79 30		0.00733
: sin. C×sin. D,	C,	90 00		10.00000
	D,	66 00		9.96073
: : CD^2,	CD,	22.21		1.34655
	CD,	22.21		1.34655
: fourth term		471.33		2.67333

3

1413.99
619.35

8)2033.34

$FE=\sqrt{254.17}=15.94$

As sin. E,	76° 30′	Ar. Co.	0.01217
: sin. B,	123 30		9.92111
: : AB,	12		1.07918
: ES,	10.29		1.01246

As sin. P,	24° 00′	Ar. Co.	0.39069
: sin. E,	76 30		9.98783
: : FS,	5.65		0.75205
: AF,	13.51		1.13057

2. The boundaries of a field ABCD are given as follow: viz. AB, S. 10½° W. 7.20 ch.; BC, S. 67° W. 12.47 ch.: CD, N. 23° W. 13.33 ch.; and DA, S. 89° E. 18 ch.; and it is to be divided into two parts ABEF and FECD, in the ratio of 3 to 4, by a line FE, running due South. Required the length of the division line FE and the distance AF. *Ans.* FE 10.10 and AF 8.12.

PROBLEM XIX.

The boundaries of a tract of land ABCDEFGHIA, *Fig.* 108, *being given, to divide it into two equal parts by a line* IN *running from the corner* I, *and falling on the opposite side* CD.

RULE.

Suppose lines drawn from I, to C and D, and calculate the area of the whole tract.

Take the corrected latitudes and departures* of IA, AB, and BC, and by balancing find the latitude and departure of CI; also calculate the area of the part IABCI; from half the area of the whole tract, subtract the area of the part IABCI, the remainder will be the area of the triangle ICNI.

Take the latitudes and departures of IC and CD, and by balancing find the latitude and departure of DI, and calculate the area of the triangle ICDI. Then,

As the area of the triangle ICDI,
Is to the area of the triangle ICNI;
So is the latitude of CD,
To the latitude of CN.

Also, As the area of the triangle ICDI,
Is to the area of the triangle ICNI;
So is the departure of CD,
To the departure of CN.

---

* It is the corrected latitudes and departures that are to be used throughout the calculation.

Now take the latitudes and departures of IC and CN, and by balancing find the latitude and departure of the division line NI; with which, find its bearing and distance.*

EXAMPLES.

1. Let the bearing of AB be N. 19° E. dist. 27 ch.; BC, S. 77° E. 22.75 ch.; CD, S. 27° E. 28.75 ch.; DE, S. 52° W. 14.50 ch.; EF, S. 15½° E. 19 ch.; FG, West, 17.72 ch.; GH, N. 36° W. 11.75 ch.; HI, North, 16.07 ch., and IA, N. 62° W. 14.88 ch.; it is required to divide the tract into two equal parts by a line IN running from the corner I, and falling on the opposite side CD.

First calculate the whole area, thus:

---

* This rule needs no demonstration.

Sta.	Courses.	Dist.	N.	S.	E.	W.	cor. S.	cor. E.	N.	S.	E.	W.	E.D.D.	W.D.D.	Multi-pliers.	N. Areas.	S. Areas.
AB	N. 19° E.	27.00	25.53		8.79		.02	.01	25.51		8.80			4.33	0.00 E		
BC	S. 77 E.	22.75		5.12	22.17		.01	.01		5.13	22.18		30.98		30.98 E		158.9274
CD	S. 27. E.	28.75		25.62	13.05		.02	.02		25.64	13.07		35.25		66.23 E		1698.1372
DE	S. 52 W.	14.50		8.93		11.42	.01	.01		8.94		11.41	1.66		67.89 E		606.9366
EF	S. 15½ E.	19.00		18.31	5.08		.01	.01		18.32	5.09			6.32	61.57 E		1127.9624
FG	West.	17.72				17.72	.01	.01		.01		17.71		12.62	48.95 E		.4895
GH	N. 36 W.	11.75	9.51			6.91	.01	.01	9.50			6.90		24.61	24.34 E	231.2300	
HI	North,	16.07	16.07				.01	.01	16.06		.01			6.89	17.45 E	280.2470	
IA	N. 62 W.	14.88	6.98			13.14	.01	.01	6.97			13.13		13.12	4.33 E	30.1801	
		172.42	58.09 57.98	57.98	49.09	49.19 49.09	.11	.10	58.04	58.04	49.15	49.15	67.89	67.89		541.6571	3592.4531 541.6571

.11 Er. S. .10 Er. E.

2)3050.7960

Area of ABCDEFGHIA (sq. ch.) 1525.3980

Half do. do. (sq. ch.) 762.6990

To find the latitude and departure of CI, *and area of the part* IABCI.

Sta.	N.	S.	E.	W.	E.D.D.	W. D. D.	Mult.	N. A.	S. Areas.
IA	6.97			13.13		30.98	0.00 E		
AB	25 51		8.80			4.33	4.33 W		110.4583
BC		5.13	22.18		30.98		26.65 E		136.7145
CI		(27.35)		(17.85)	4.33		30.98 E		847.3030
	32.48	32.48	30.98	30.98	35.31	35.31			1094.4758

Area of IABCI (sq. ch.) 547.2379
Half area of ABCDEFGHIA 762.6990

Area of ICNI (sq. ch.) 215.4611

To find the area of ICDI.

Sta.	N.	S.	E.	W.	E. D. D.	W. D. D.	Mult.	N. A.	S. Areas.
IC	27.35		17.85			13.07	0.00 E		
CD		25.64	13.07		30.92		30.92 E		792.7888
DI		(1.71)		(30.92)		17.85	13.07 E		22.3497
	27.35	27.35	30.92	30.92	30.92	30.92			815.1385

Area of ICDI (Sq. ch.) 407.5692

As area of ICDI, 407.57 Ar. Co. 7.38980
: area of ICNI, 215.46 - - - - - - - - 2.33337
: : latitude of CD, 25.64 S. - - - - - - - 1.40892

: latitude of CN, 13.55 S. - - - - - - - 1.13209

As area of ICDI, 407.57 Ar. Co. 7.38980
: area of ICNI, 215.46 - - - - - - - - 2.33337
: : departure of CD, 13.07 E. - - - - - - - 1.11628

: departure of CN, 6.91 E. - - - - - - - 0.83945

To find the latitude and departure of NI.

Sta.	N.	S.	E.	W.
IC	27.35		17.85	
CN		13.55	6.91	
NI		(13.80)		(24.76)
	27.35	27.35	24.76	24.76

To find the bearing and distance of NI.

As diff. of lat. of NI, 13.80 S. Ar. Co. 8.86012
: dep. do. 24.76 W. - - - - - - 1.39375
: rad. - - - - - - - - - - - - - - 10.00000

: tang. bearing of NI, S. 60° 52′ W. - - - 10.25387

As rad. - - - - - - - - - - Ar. Co. 0.00000
: sec. bearing of NI, 60° 52′ - - - - - 10.31261
: : diff. lat. do. 13.80 - - - - - - - 1.13988

: dist. NI, 28.35 ch. - - - - - - - - - 1.45249
Hence IN bears, N. 60° 52′ E. dist. 28.35 ch.

2. Given the boundaries of a tract of land as follow; *viz.* 1st. S. 35¼° W. 11.20 ch.; 2d. N. 45° W. 24.36 ch.; 3d. N. 15¼° E. 10.80 ch.; 4th. S. 77° E. 16 ch.; 5th. N. 87½° E. 21.50 ch.; 6th. S. 60° E. 14.80 ch.; 7th. South, 10.91 ch.; 8th. N. 85° W. 29.28 ch. to the place of beginning; to divide the tract into two equal parts by a line running from the first station and falling on one of the opposite sides; the bearing and distance of the division line are required. *Ans.* N. 7° 18′ E. 15.28 ch.

CHAPTER V.

VARIATION OF THE COMPASS.

A MERIDIAN indicated by the magnetic needle is not, in general, a true one; for the needle does not point truly to the north point of the horizon, but varies from it, in some places to the eastward, and in others to the westward.

The angle contained between the true meridian and that indicated by the needle, is called the *variation of the compass.*

The variation is named *east* or *west*, according as the north end of the needle points to the eastward or westward of the true north.

As the variation is different in different places, so also, in the same place, it does not remain the same, but differs sensibly in the course of a few years. Hence, in running a line that was run a number of years previously, the bearing will be found different from what it was at that time; this, together with some difference in compasses, causes many difficulties, and frequently inaccuracies, in tracing old lines.

The easiest way to guard against those difficulties and inaccuracies would be to make and return the surveys according to the true, and not the magnetic bearings. In order to do this, it will be necessary to know the variation of the compass for the place in which the survey is made; and this may readily be found by first tracing a meridian line in the following manner.

To draw a true meridian line by means of the greatest elongation of the pole star.

The pole star is situated about 1½° from the true pole, and therefore apparently revolves round it, in a small circle, once in about 23 h. 56 m. When at its greatest distance *east* or *west* from the true pole, it is said to be at its greatest east or west *elongation*. It is therefore evident that in the course of one apparent revolution it must be twice at its greatest elongation, once to the east and once to the west.

The following tables exhibit the times, nearly, of the greatest eastern elongations of the pole star for six months of the year, and of the greatest western elongations for the other six months. The other greatest elongations take place in the day time, and are therefore invisible. Some of those inserted in the tables are also invisible; because they occur, either before daylight is gone, in the evening, or after it has returned, in the morning. The most of those in the 3d, 4th, 9th, and 10th months are in this situation.

The time in the tables is reckoned from noon; and therefore when it is less than 12 hours, the greatest elongation takes place in the evening of the same day; but when it exceeds 12 hours, if 12 hours be subtracted from it, the remainder will be the time of greatest elongation in the morning of the following day.

Eastern Elongation.

Days.	4 mo. (Ap.)		5 mo. (Ma.)		6 mo. (Ju.)		7 mo. (July)		8mo. (Aug.)		9 mo. (Sep.)	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
1	18	18	16	26	14	24	12	20	10	16	8	20
7	17	56	16	3	14	0	11	55	9	53	7	58
13	17	34	15	40	13	35	11	31	9	30	7	36
19	17	12	15	17	13	10	11	7	9	8	7	15
25	16	49	14	53	12	45	10	43	8	45	6	53

Western Elongation.

Days.	10 mo. (Oc.)		11 mo. (No.)		12 mo. (De.)		1 mo. (Ja.)		2 mo. (Feb.)		3 mo. (Mar.)	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
1	18	18	16	22	14	19	12	2	9	50	8	1
7	17	56	15	59	13	53	11	36	9	26	7	38
13	17	34	15	35	13	27	11	10	9	2	7	16
19	17	12	15	10	13	00	10	44	8	39	6	54
25	16	49	14	45	12	34	10	18	8	16	6	33

In order to determine a true meridian, by the method here used, it is necessary to know the bearing of the pole star, called its *azimuth*, at the time of its greatest elongation. This depends on the latitude of the place, and the distance of the star from the pole. This distance is called the *polar distance* of the star. It is subject to a small annual *diminution*, which is called its annual *precession*. The polar distance of the star on the 1st. of the 1st. month (January) 1830, was 1° 35′ 51″; and its annual precession is 19.3″.

The polar distance may be found for any subsequent time by multiplying 19.3″, by the interval between the 1st. of the year 1830, and the given time, and subtracting the product from 1° 35′ 51″. Thus, suppose the polar distance of the pole star was required for the 1st. of the 7th. month, (July) 1845. The interval is 15.5 years; and 19.3″×15.5 gives 299.15″=4′ 59″. From 1° 35′ 51″, take 4′ 59″, and we have 1° 30′ 52″ for the polar distance of the star, at the time proposed.*

When the polar distance of the pole star is known, its azimuth, at the time of greatest elongation may be found by the following proportion.

As radius,
Is to the secant of the latitude of the place,
So is the sine of the polar distance,
To the azimuth.

This azimuth will be *east* or *west*, according as the elongation is *east* or *west;* and consequently its name will be known from the preceding tables.

As an example, let the azimuth of the pole star, at Philadelphia, latitude 39° 57′, be required, for the 1st. of the 7th. month (July) 1845. The polar distance found above is 1° 30′ 52″; and it may be taken 1° 31′ without material error.

As radius - - - - - - - -	Ar. Co.	0.00000
: secant of lat. 39° 57′ - - - - - - - -		10.11543
:: sin. of pol. dist. 1 31 - - - - - - - -		8.42272
: sin. of azimuth 1° 59′ E. - - - - - - -		8.53815

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* The polar distance obtained as above, is called the *mean* polar distance; and it is sufficiently accurate for our present purpose. To obtain the *true* polar distance, two small corrections called *aberration* and *nutation*, would have to be applied.

In order to observe the greatest elongation of the pole star, it will be necessary to prepare the following simple apparatus.

Place two posts firmly in the ground, about three feet apart, and nearly east and west from each other; the heights of the posts, which should be the same, may be about two or three feet; on those posts, place a thick board or plank, five or six inches wide, and nail it fast to each of them, taking care that it be level or nearly so; take a piece of board, a foot or eighteen inches long and four or five wide, and near the middle of it fasten a compass-sight perpendicularly; this board is to slide on the horizontal one already mentioned.

Take a stiff pole 18 or 20 feet in length, and fix it in an inclined position, in such a manner that a plumb line suspended from the upper end, may be nearly north, from the middle of the horizontal board, and about ten feet distant from it; the elevation of the pole must be such that the pole star, when viewed through the compass sight placed on the horizontal board, may appear a few inches below its upper end; when in this position the lower end should be fastened in the ground, and the pole should be supported by a couple of crotchets placed near the middle. The plumb should weigh a pound or more, and should swing in a vessel of water, in order to prevent the line being agitated by the motion of the air.

The apparatus being prepared, proceed, about 15 or 20 minutes previous to the time of greatest elongation as indicated by the table, to make the observation as follows: Let an assistant hold a lighted candle near the plumb line, so as to illuminate it and render it distinctly visible; place the small board with the compass-sight attached to it, on the horizontal one, and move it east or west as the case may require, till the pole star, plumb line, and aperture in the compass-sight are all in a direct range. If the star should be deviating to the east, it will leave the plumb-line to the west; and the contrary, if deviating to the west; keep therefore shifting the sight, till the star appears stationary behind the plumb-line; which it will do for several minutes at the time of its greatest elongation, and will then recede from the line on the contrary side from which it did before it became stationary. The compass-sight must not be moved after the star has attained its greatest elongation; but the aperture in it being then in a direct range with the plumb line and star, the board to which the sight is fixed, must be fastened to the one on which it slides, by a small tack passing through each end. This being done let an assistant take a straight stake, with a piece of lighted candle stuck on it, and go north to the distance of 30 or 40 perches; then looking through the compass-sight, direct him to set up the stake perpendicularly, and in such a situation that the candle stuck on the top may appear exactly behind the plumb-line; when thus placed, let it be firmly fixed in the ground. Next, let another straight stake be set up in the same manner near the plumb-line; the remaining part of the work may then be left till morning.

Measure accurately the distance between the two stakes. Then,

As radius,
Is to the tangent of the azimuth;
So is the distance between the stakes, in feet,
To a fourth term, in feet.

Lay off the distance contained in this fourth term from the northerly stake, and perpendicular to a line joining the two stakes; it must be laid off towards the *west* if the azimuth is *east*, but towards the *east* if the azimuth is *west*. Next remove the northerly stake, and set it up at the other extremity of the distance thus laid off; then a straight line joining the two stakes will be a true *meridian* line.

To obtain the variation, set up a compass in the place of the southerly stake, and direct the sights truly to the northerly one; the needle will then point out the variation, which will be *east* or *west*, according as the north end of the needle points to the *east* or *west* of the north point of the compass. The whole process is so simple, that an example is deemed unnecessary.

It has already been observed, that the greatest elongations of the pole star are invisible during the greater part of the 3d and 4th months, and also of the 9th and 10th; consequently a meridian line cannot be obtained by the preceding method, during those periods. But as the surveyor may generally choose his time for tracing a meridian line, and as, when this is done, he can at any time obtain the variation, it is thought unnecessary to introduce other methods. Those, however, who would wish to be acquainted with simple and accurate methods of tracing a meridian line at any season of the year, may consult a pamphlet on the subject by *Andrew Elicott, A.M.* from which the substance of the preceding method is extracted; and which contains others suited to those times of the year in which this cannot be applied. It may not be improper also to observe, that the second volume of the *American Philosophical Transactions* contains an essay by *Robert Patterson*, *Professor of Mathematics in the University of Pennsylvania*, in which is given a method for obtaining the variation to a sufficient degree of accuracy for any purpose in surveying, and which has this advantage, that the observation may be made at any season of the year, and at any time in the evening. There are also other methods besides those alluded to above, by which a meridian line may be traced, or the variation of the compass determined; but as the most of them require expensive instruments for making the observations, it is thought unnecessary to notice them in this work.

To obtain the true bearings of a survey, from the magnetic ones, the variation being given.

If the variation be *east*, add it to the north-easterly and south-westerly bearings, and subtract it from those that are north-westerly or south-easterly; but if the variation be *west*, add it to the north-westerly and south-easterly bearings, and subtract it from those that are north-easterly or south-westerly; this being done, the true bearings are obtained.

To find the difference between the present variation, and that at a time when a tract of land was formerly surveyed, in order to trace or run out the original lines.

Go to any part of the premises, where any two adjacent corners are known; and if one can be seen from the other, take its bearing; which compared with that of the same line in the former survey, shows their difference. But if one corner cannot be seen from the other, run the line according to the given bearing, and measure the nearest distance between the line so run, and the corner; then,

As the length of the given line,
Is to the said distance;
So is 57.3 degrees.*
To the difference of variation required.

EXAMPLE.

Suppose it be required to run a line, which some years ago bore N. 45° E. dist. 20 ch. and in running this line by the given bearing, the corner is found 20 links to the left hand; what allowance must be made on each bearing to trace the old lines; and what is the present bearing, by the compass, of this particular line?

L. L. Deg.
As 2000 : 20 : : 57.3
20

2000)1146.0(0° 34′

Consequently 34 minutes, or a little more than half a degree, is the allowance required; and the line in question bears N. 44° 26′ E.

Note. The above rule is simple and sufficiently accurate when the distance between the sought corner and random line, is small. But when this distance is considerable, it will be better to find the angle by trigonometry.

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* 57.3 is the radius (nearly) of a circle in such parts as the circumference contains 360.

ON LOCAL ATTRACTION.

It is well known that iron or any ferruginous substance attracts the magnetic needle, and consequently when near, will draw it aside from the position in which it would otherwise settle. And as the earth in many places contains, near its surface, substances of this kind, the needle will not unfrequently be attracted from its true direction. The surveyor ought therefore, at each station, to take a back sight to the preceding one; and if he arrive at one at which the compass does not reverse truly, he may conclude, provided no error was committed in taking the bearing at the last station, that at the present one, the needle is affected by some local attraction. In such a case, he should first determine whether any error was committed at the last station, and if none is found, take the difference between the bearing from the last station and the reverse bearing, which will be the local variation of the needle at the present station. This variation must be applied, according to its name, to the bearing of the following station.

If at the first and second station of a survey the compass is found not to reverse truly, the surveyor will be at loss to know which of them is affected by attraction. But by taking another station, either within or without the survey, and taking its bearing from each of those stations, and the bearing of each of those from it, he may, in general, determine at which of them the attraction exists.

Note.—The area of the survey is not affected by the general variation, because it is the same at each station. But where local attraction exists and causes a variation in the position of the needle, as this variation will be different at different stations, it will, unless ascertained, and allowed on the corresponding bearings, materially affect the truth of the survey.

CHAPTER VI.

MISCELLANEOUS QUESTIONS.

1. A circular fish-pond is to be dug in a garden, that shall take up just half an acre: what must be the length of the cord that strikes the circle?

Ans. 27.75 yards.

2. Two sides of a triangle are 20 and 40 perches respectively: required the third side, so that the content may be just an acre.

Ans. Either 23.099 or 58.876 perches.

3. In 110 acres of statute measure, in which the pole is 5.5 yards, how many Cheshire acres, where the customary pole is 6 yards; and how many of Ireland, where the pole in use is 7 yards?

Ans. 92 A. 1 R. 29 P. Cheshire; 67 A. 3 R. 25 P. Irish.

4. The ellipse in Grosvenor square, London, measures 840 links the longer way, and 612 the shorter, within the rails; now the wall being 14 inches thick, it is required to find what quantity of ground it encloses, and how much it stands upon.

Ans. It encloses 4 A. 0 R. 6 P. and stands on 1760¼ square feet.

5. Required the dimensions of an elliptical acre, with the greater and less diameters in the ratio of 3 to 2.

Ans. 17.481 by 11.654 perches.

6. The three sides of a triangular field, containing 6 A. 1 R. 12 P. are in the ratio of the three numbers, 9, 8, 6, respectively; required the sides.

Ans. 59.029, 52.47, and 39.353 perches.

7. In a pentangular field, beginning with the south side and measuring round towards the east, the first or south side is 27.35 ch., the second 31.15 ch., the third 23.70 ch., the fourth 29.25 ch., and the fifth 22.20 ch.; also the diagonal from the first angle to the third is 38 ch., and that from the third to the 5th. 40.10 ch.; required the area of the field. *Ans.* 117 A. 2 R. 39 P.

8. Required the dimensions of an oblong garden, containing three acres, and bounded by 104 perches of pale fence.* *Ans.* 40 P. by 12.

9. How many acres are contained in a square meadow, the diagonal of which is 20 perches longer than either of its sides? *Ans.* 14 A. 2 R. 11 P.

10. A gentleman has a garden 100 feet long and 80 broad, and a gravel walk is to be made of equal width half round it; what must be the width of the walk, so that it may take up just one fourth of the ground.

Ans. 11.8975 feet.

11. A person has a circular yard that is 150 feet in diameter, and wishes a walk of equal width made round it within the fence: required the width of the walk so that it may occupy a fifth part of the ground.

Ans. 7.918 feet.

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* This question may be neatly constructed by 28, 6 *Playfair's Geometry*. It may not be improper also to observe, that the 2d question, and all those following the 8th, admit of neat geometrical constructions.

12. From a point within a triangular field the sides of which were equal, I measured the distances to the three angles, and found them 12.5, 10, and 7.5 chains, respectively; required the area. *Ans.* 12 A. 1 R. 23 P.

13. On examining the field-notes of a lot of ground of which I wished to know the content, I found them as follow: 1st. S. 72° W. 24 per., 2d. North, 38 per., 3d. N. 82½ E. 41 per., 4th. ——, 20 per., 5th. S. 80° E. 11.5 per., 6th. S. 26° W. 22 per., and 7th. ——, 37 per., to the place of beginning. The bearings of the 4th and 7th boundary lines were illegible; but the data remaining being sufficient, the area is required.

Ans. 12 A. 3 R. 2 P.

14. It is required to lay out 4½ acres of land in a triangular form, so that the length of one side may be 15 chains, and the lengths of the other sides in the ratio of 2 to 3; what must be the lengths of those sides?

Ans. 7.7914 and 11.6871 chains; or 29.58536 and 44.37804 chains.

15. It is required to lay out five acres of ground in a triangular form to be bounded by 135 perches of fence; the length of one side is to be 50 perches; what must be the lengths of the other sides?

Ans. 33.3785 and 51.6215 perches.

16. The area of a rectangular field is 7½ acres and the length of the diagonal 50 perches: required the sides.

Ans. 30 and 40 perches.

17. In a rectangular tract of land, containing 58 A. 3 R. 8 P. the difference of the lengths of the sides is just equal to the difference between the lengths of the longer side and the diagonal; hence the sides are required.

Ans. 21 and 28 chains.

18. The boundaries of a tract of land are as follow: 1st. N. 14° W. 15.20 ch.; 2d. N. 70½° E. 20.43 ch.; 3d. S. 6° E. 22.79 ch.; 4th. N. 86½° W. 18 to the place of beginning; within the tract there is a spring, the bearing and distance of which, from the 2d corner, is S. 75° E. 7.90 ch. It is required to cut off 10 acres from the west side of this tract by a straight line running through the spring; what must be the distance of the division line from the 1st corner, measured on the fourth side.

Ans. 4.6357 chains.

19. The boundaries of a quadrilateral tract of land are as follow: 1st. N. 35¼° E. 23 ch.; 2d. N. 75½° E. 30.50 ch.; 3d. S. 3¼° E. 46.49 ch. and 4th. N. 66¼° W. 49.64 ch., to the place of beginning. This tract is to be divided into four equal parts by two straight lines, one of which is to run parallel to the 3d side; required the distance of the parallel division line from the first corner, measured on the 4th side; also the bearing of the other division line, and its distance from the same corner, measured on the first side.

Ans. Distance of the parallel division from the first corner 32.50 chains; the bearing of the other, S. 88° 22′ E. and its distance from the same corner 5.99 chains.

CHAPTER VII.

OF THE THEODOLITE.

A Vertical Angle is any angle in a plane perpendicular to the horizon. Consequently angles of elevation and depression are vertical angles.

A *Theodolite* is an instrument used to measure both horizontal and vertical angles.

By the aid of a theodolite, surveys may be much more accurately made than with the compass, especially when the tract is large or the ground hilly, or where there is local attraction. Before describing the theodolite, it will be best to notice separately one or two of its appendages.

Of the Spirit Level.

The *Spirit Level* consists principally of a cylindrical glass tube, nearly, but not entirely, filled with alcohol, or some other fluid. The inner part of that side of the tube which, when in use, is to be uppermost, is ground from end to end into a regular curve, having its convexity upwards. In consequence of this curvature in the upper part of the cavity, the *air bubble*, or part not occupied by the fluid, must be at the middle of the tube when the *axis of the level*, that is, the straight line passing lengthwise through its middle, is in a horizontal position. And conversely the axis must be horizontal when the instrument is so placed that the bubble stands at the middle of the tube.

Of the Vernier.

A *Vernier* is a graduated index which serves to subdivide the smallest divisions of a graduated arc or straight line.

Verniers are somewhat different according to the value of the divisions which they are to subdivide and the degree of precision they are designed to give; but the principle of construction is the same in all. The following description applies to the vernier attached to the common theodolite, the limb of which is divided into degrees and half degrees, numbered from 0° to 360°; and the vernier subdivides the half degrees to minutes.

In Fig. 115, AB represents a part of the graduated limb, and CD the vernier; the whole being drawn on an enlarged scale. The extent of the vernier is exactly equal to 29 half degrees, or 870 minutes, on the limb, and is divided into 30 equal parts, numbered from 0 to 30. Each division of the vernier contains therefore 29 minutes. Hence it is evident that when the 0, or *zero* line of the vernier exactly coincides, as in the figure, with a division line on the limb, the first division line of the vernier must be one minute behind the line on the limb first following that with which the zero of the vernier coincides; the second line of the vernier must be two minutes behind the second on the limb; the third line on the vernier must be three minutes behind the third on the limb; and so on. If then, the vernier were to be moved forward till its first division line coincided with the first on the limb, the zero of the vernier would be one minute past the line on the limb with which it before coincided; if moved till the second lines coincided, the zero of the vernier would be two minutes past the same line; and in like manner for other coincidences. It therefore follows that for any position of the vernier, the number of the division line on it which coincides with one on the limb, must express the number of minutes that the zero of the vernier is past the division line on the limb, next preceding it.

The arc indicated by the vernier index in any position is the arc intercepted in the direction in which the degrees are numbered between the zero line of the limb and the zero line of the vernier. Hence to find the arc, or as it is technically expressed, to *read off* the arc, we must add to the arc expressed by the number of whole degrees intercepted and the odd half degree, if there is one, the number of minutes indicated by the *number* of that division line on the vernier which coincides, or is the nearest to coincidence, with one on the limb. Thus, as the zero of the vernier in Fig. 115 exactly coincides with the division line on the limb, numbered 50, the arc indicated is 50°. In Fig. 116, the zero of the vernier is past the line on the limb denoting 52° 30′, and the 21st division line of the vernier coincides with a line on the limb. The arc indicated is therefore 52° 51′.

Sometimes it is requisite that the vernier should serve to read off an arc on either side of the zero line. In this case the zero of the vernier is placed at its middle, and the division lines have two sets of numbers, as in Fig. 117. The *upper* numbers are used when the zero of the vernier is to the *right* of the zero of the arc, and the *lower* ones when it is to the *left*. The arc indicated by the vernier in the position that it has in the figure, is 2° 12′ to the right.

To determine the reading of a vernier, applied to a graduated arc in which the value of the least division is more or less than half a degree, we must divide this value by the number of divisions on the vernier, and the quotient will indicate the reading that the vernier is intended to give. In the nautical instrument called a sextant, the value of the least division on the limb is usually 10 minutes, and the vernier is divided into 60 equal parts. Hence 10 minutes, or 600 seconds, divided by 60, gives 10 seconds for the reading of the vernier.

Description of the Theodolite.

The Theodolite is represented in Fig. 109. When in use, the lower circular plate AB is screwed fast to a three-legged stand or tripod, the upper part of which is represented in the figure. The circular plate CD has a hollow axis passing through it at right angles at its centre, and firmly attached to it. The lower part of the axis terminates in a ball, to which it is fastened by a screw. This ball is partly enclosed in a socket projecting from the upper side of the plate AB; the opening in the upper part of the socket being larger than the axis, so as to allow the latter some motion in every direction. In the lower plate AB, four screws, called *levelling screws*, are inserted, standing opposite each other in pairs, the tops of which press against the under side of the plate CD. These screws are turned by milled projections or heads, two of which are shown in the figure. By turning them in opposite directions, the position of the plate CD may be changed so that it may be made level, even when the lower plate AB has considerable inclination.

The part GH of the instrument consists of two circular plates in close contact with each other. The lower one is called the *graduated plate*, and its chamfered edge, which is usually made of silver, is called the *limb* of the instrument. To the central part of this plate, a hollow axis is attached, the cavity of which fits to the outside of the axis of the plate CD, so that the former may move easily and steadily about the latter. The lower part of the axis is embraced by a clamping-piece that may be tightened or loosened by the screw E. When the clamp is loose, the graduated plate may be turned round by the hand; but when it is made fast, the axis of the graduated plate, and consequently the plate itself, becomes firmly connected with the plate CD, and also, when the levelling screws are tight, with the stand of the instrument. The graduated plate may however, when thus connected, be moved a small distance either way by turning the screw F, called a *tangent-screw*, which gives it a slow motion. Around the axis of the graduated plate is another hollow axis, with which a telescope, called the *lower* telescope, is connected. When the axis of the graduated plate is clamped fast, this axis and the telescope may be made to revolve by turning the milled head I, and may be secured in any position by the screw K, which clamps the axis to the graduated plate.

The plate immediately above the graduated plate is called the *vernier plate*. It has, at its centre, a solid axis which fits into the cavities of the hollow axes of both the graduated plate and plate CD. When the screw L, which serves to clamp the vernier plate to the graduated plate, is loosened, the former may be turned round by hand; and when this screw is made tight, a slow motion may be given to the vernier plate by the tangent-screw M. The vernier plate has two, or sometimes three, verniers at different parts of its edge, which are chamfered for the purpose. When there are only two, they are placed directly opposite to each other. When there are three, they are placed at equal distances around the edge. The microscope S is used to enable the eye more certainly to distinguish the line on the vernier that coincides with one on the limb. Two levels are placed on the vernier plate, at right angles to each other; one of which is shown in the figure.

The frame which supports the vertical semicircle and *upper* telescope with its attached level, is attached to the vernier plate by three screws at equal distances from one another. The immediate supports of this telescope are called *wyes*, or Y's, from their resemblance to the letter Y. The telescope is held in its place by two curved pieces, moveable on joints, which pass over it and are fastened by the pins T and U. When these pins are taken out, the pieces may be turned back and the telescope taken from its place and *reversed*, that is changed end for end.

In the tube of the telescope a flat ring is placed at right angles to its axis, and connected with the tube by four screws, opposite to each other in pairs; the heads of three of which, *b*, *c*, and *d*, are shown. Two spider's lines or very fine wires, at right angles to each other, are attached to the ring, in the directions respectively of each pair of screws, and intersecting each other in the centre of the ring. At each end of the principal tube, and fitting it on the inside, a short moveable tube is inserted. The one at the end to which the eye is applied, and which usually contains several glass lenses, may be moved out or in, by a small pin attached to its lower side, and may thus be so adjusted as to render the spider's lines distinctly visible. The tube at the other end, which contains one lens, may be moved out or in, by turning the milled head V, and may be thus so placed as to render an object to which the telescope is directed, as distinct as its distance permits.

A straight line in the direction in which the intersection of the spider's lines or wires is seen by an eye placed at the eye end of the telescope, is the *line of sight* of the telescope, and is technically called the *line of collimation*. The telescope is said to be *directed* to any point in an object, when it is so placed that the line of collimation passes through the point; or which is the same, when the point is directly behind the intersection of the spider's lines.

The semicircle PQ is called the *vertical limb* of the instrument. That face of it which is not seen in the figure is divided into degrees and half degrees, numbered each way from a line taken as a zero or 0 line; and the arc is read by a vernier numbered as in Fig. 117. The other face has two sets of unequal divisions on it, numbered each way from a zero line. One of these denotes the difference between the real distance of an object to which the upper telescope is directed and its horizontal distance, expressed in 100th parts of the distance. The other denotes the vertical distance of the object, above or below a horizontal line, passing through the instrument, expressed in 100th parts of the horizontal distance. The vertical limb is moved so as to give to the telescope different inclinations to the horizon, by means of the milled head N.

At the bottom of the frame which supports the vertical limb and upper telescope, and directly over the centre of the vernier plate, there is a compass box, containing a magnetic needle. This part of the instrument may be used to take the bearing of an object in the same manner as a common compass.

ADJUSTMENTS OF THE THEODOLITE.

In order that the theodolite may be in a good state for use, the line of collimation of the upper telescope should exactly coincide with the axis of the telescope; the axis of the attached level should be parallel to this line; the axes of the levels on the vernier plate should be parallel to this plate; the line of collimation of the telescope should, when the milled head N is turned, move in a plane perpendicular to the vernier plate; and when this line is brought parallel to the vernier plate, the zero of the vertical limb should coincide with the zero of its vernier. Previous therefore to using the instrument, the different parts should be examined, and *adjusted* if necessary. This may be done by the following methods.

FIRST ADJUSTMENT.

To make the line of collimation coincide with the axis of the telescope.

The instrument being firmly screwed on the tripod and the legs of the latter being sufficiently extended to ensure its remaining fixed in its position, loosen the clamp screw L, and turn the vernier plate till the telescope points to some distant object having on it a small well-defined point. Then, having fastened the screw L, move the telescope by the tangent-screw M, and milled head N, till the line of collimation is directed exactly to the point.

Revolve now the telescope in its Y's, half round, that is, till the level, from being directly below the tele scope is directly above it. If the horizontal spider's line still coincides with the point, it requires no adjustment; but if it does not, diminish the distance one-half, by loosening one of the screws *c* and *d* and tightening the other; and then bring the line to coincide with the point by means of the milled head N. Revolve the telescope round to its first position, and if the horizontal line and point do not then coincide, repeat the operation till the coincidence has place in both positions. In a similar manner the vertical line may be adjusted. When both adjustments are complete, the line of collimation should coincide with the same point during a complete revolution of the telescope in its Y's.

SECOND ADJUSTMENT.

To make the axis of the level attached to the upper telescope parallel to the line of collimation.

Turn the vernier plate till the telescope comes directly over two of the levelling screws; and if the telescope is not nearly in a horizontal position, make it so by turning the milled head N. Then turn the levelling screws over which the telescope stands, in opposite directions, till the bubble of the level stands exactly at the middle of the tube; observing to keep the screws firm against the plate CD. When this is done, reverse the telescope in its Y's, and if the bubble does not stand at the middle of the tube, correct *half* of the deviation by one of the screws *m* and *n*, which serve to raise or depress the ends of the level, and then, by the levelling screws, bring the bubble to the middle. Again reverse the telescope and repeat the correction if necessary.

Revolve now the telescope in its Y's so as to bring the level a considerable distance from its proper or lowest position, and if the bubble deviates from the middle of the tube, make the requisite correction by means of two screws, *p* and *q*, which move the end of the level laterally, one of which is shown at *p*. When this part of the adjustment has been so made that the bubble will remain in the middle of the tube while the telescope is revolved either way, the first part of the adjustment should, by again reversing the telescope, be examined, and repeated if necessary.

THIRD ADJUSTMENT.

To make the axes of the levels on the vernier plate parallel to that plate.

Turn the vernier plate till the upper telescope stands over two of the levelling screws; then one of the levels on this plate will be parallel to these two screws, and the other will be parallel to the other two. By means of these levelling screws bring the bubbles of both levels to stand in the middles of their respective tubes. Then move the vernier plate 180°, and if the bubble in either of the levels deviates from the middle, correct one-half of the deviation by one of the screws at its ends, and the other half by the levelling screws, parallel to it; and if the bubble of the other level also deviates from the middle, proceed in the same way to correct the deviation. Repeat the operations till the bubbles of both levels will remain at the middles of their respective tubes during a complete revolution of the vernier plate.

FOURTH ADJUSTMENT.

To make the axis about which the vertical limb revolves, parallel to the vernier plate.

Turn the vernier plate till the upper telescope is directed towards a well-defined, elevated point, on a house or other object, not very remote, and having clamped the plate, direct the telescope by means of the tangent-screw M and milled head N, exactly to the point. Then turn the milled head N till the line of collimation coincides with some well-defined point near the ground; or, if none such is found, let an assistant make a suitable mark in the direction of the line of collimation when thus brought nearly horizontal. This being done, reverse the telescope in its Y's; and, proceeding as before, direct it to the elevated point. Then, if by turning the milled head N, the line of collimation is brought to coincide with the lower point or mark, the axis of the vertical limb is parallel to the vernier plate; but if this is not the case, the adjustment must be made by the screws which attach the upper frame to this plate.

FIFTH ADJUSTMENT.

To adjust the vernier of the vertical limb, or determine the correction which should be made, to allow for its deviation from correct adjustment.

Direct the upper telescope to some elevated point and note the angle of elevation indicated by the vernier. Reverse the telescope in its Y's, and again direct it to the same point, and note the angle of elevation. If the angles are the same, the vernier is properly adjusted. If they differ, the position of the vernier requires adjustment; and this may be effected by the screw *v*, which is one of those that fasten the upper frame to the vernier plate.

Instead of changing the position of the vernier, we may take half the difference of the two angles of elevation as a *correction*, to be added to all those angles of elevation and subtracted from those of depression, that are taken with the telescope in that position in its Y's, which gave the least of the two angles; but to be applied in a reverse manner when the position of the telescope is that which gave the greater angle.

SIXTH ADJUSTMENT.

To make the axis about which the lower telescope revolves vertically, perpendicular to the axis of the instrument.

Turn the vernier plate till the levels on it are respectively parallel to a pair of opposite levelling screws, and by means of these screws bring the bubbles to stand in the middles of the tubes; the instrument is then levelled, and its axis is perpendicular to the horizon. Suspend a plumb-line of considerable length at a short distance from the instrument, and loosening the clamping screw K, turn the milled head I, till the telescope is directed to the line, and then fasten the clamping-screw. Now, applying the hand to the eye-end of the telescope, move it vertically, and observe whether it continues directed to the line, throughout its whole extent. If it does, the axis is properly adjusted; if it does not, the adjustment may be made by two small screws which move the remote end of the axis vertically.

The lower telescope being used only as a guard to ascertain whether or not the horizontal limb of the instrument remains fixed while the vernier plate is made to revolve, in order to direct the upper telescope to an object, requires no other adjustment than the above, except those for distinct vision of the spider's lines and object.*

In extensive practical operations, the above adjustments should be examined, and corrected if necessary, not only before the commencement, but every day or two during their continuance.

Of the arc of the horizontal limb, corresponding to a given position of the vernier plate.

When there is but one vernier, the arc indicated by it is regarded as the corresponding arc. When there are two or three, it is usual to distinguish them by calling one A, another B, and the third, if there is a third, C, and to consider the arc indicated by the vernier A, as expressing the position of the vernier plate, at least very nearly; the readings of the other verniers being used merely as a test, or means of correcting the former. We therefore note the arc indicated by the vernier A. Then note the minutes of the arc indicated by the vernier B; but instead of the number of degrees indicated by it, we take either the number indicated by the vernier A, or this number increased or diminished by a unit, so that the arc set down for the vernier B, may be very nearly the same as that for the vernier A. If there is a third vernier C, we proceed in the same manner. Then the sum of the arcs obtained for each vernier, divided by the number of verniers,* will give the value of the arc corresponding to the given position of the vernier plate, or, as it is sometimes expressed, the *arc indicated by the verniers.* Thus, if we suppose the instrument to have three verniers, and that for a given position of the plate, the reading of the vernier A is 142° 2′, of B, 261° 58′, and of C, 22° 3′; then, instead of these quantities for B and C, we write for B, 141° 58′, and for C, 142° 3′. Adding together 142° 2′, 141° 58′, and 142° 3′, and dividing the sum by 3, we obtain 142° 1′, for the arc indicated by the verniers.

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* When the foregoing adjustments have been completed for the first time, there is another examination which it is well to make. Direct the upper telescope to some well-defined point near the horizon, and note the arcs on the horizontal limb, indicated by the different verniers. Then having directed the lower telescope to the same point, fasten its clamping-screw K; examining first, however, to see that the upper telescope has not changed its position, or if it has, bringing it back by the tangent-screw F. Reverse now the upper telescope in its Y's, and again direct it to the point; examining at the same time to see that the lower telescope has not changed its position, or, if it has, bringing it back by the tangent-screw F. Note the arcs indicated by each of the verniers; and subtract the arc indicated by each vernier in the former position from that in the latter, increasing that of the latter by 360°, if necessary. Add together the remainders, and divide the sum by the number of verniers. If the quotient is 180°, we infer that the axis about which the upper telescope revolves is, as it ought to be, at right angles to the line of collimation of the telescope. If the quotient differs materially from 180°, the instrument is imperfect, except one of the Y's is laterally adjustable. Where this is not the case, the imperfection can only be well remedied by an instrument-maker. If the remainders mentioned above differ much from each other, we infer that the instrument has not been well centered, or not well divided.

PROBLEM I.

To measure with the Theodolite the horizontal angular distance of two objects, as seen from a given station.

By means of a plumb-line suspended from the centre of the plate which forms the top of the tripod, set the centre of the instrument directly over the station-mark, and then level it, as directed in the sixth adjustment. Direct the upper telescope to the object which stands to the *left*, when the face is turned towards the angle to be measured, and note the readings of the verniers. Then, having directed the lower telescope to the same object and fastened its clamping-screw K, direct the upper telescope to the other object; and note the readings of the verniers; observing first however, whether there has been any change in the position of the lower telescope; and if there has, bringing it back to the object at the left by means of the tangent-screw F, and again by the tangent-screw M, adjusting the direction of the upper telescope to the object at the right. Subtract the arc which expresses the first position of the vernier plate, found from the readings of the verniers, from that which expresses the second position, found in like manner, increasing the latter by 360°, if necessary, and the remainder will be the angle required.*

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* When, as is commonly the case, the number of the degrees of the arc for each vernier is the same, we need only divide the sum of the minutes of the arcs, by the number of verniers, and annex the quotient to that number of degrees.

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* Sometimes, in order to give greater precision to the result, the operation is repeated two or three or more times. When this is done, the verniers need only be read at the first and last positions of the vernier plate. The method of proceeding is as follows: After the upper telescope has been directed to the object at the right, loosen the clamping-screw E, and turn the instrument round till the upper telescope points towards the object at the left, then fasten the screw, and by means of the tangent-screw F, direct the telescope accurately to the object. Then, having directed the lower telescope to this object, and fastened its clamping-screw, direct the upper telescope again to the object at the right, in the usual way. The vernier plate must then have moved, from its first position, a distance equal to twice the measure of the angular distance of the objects. If the operation be again repeated, the distance moved by the plate must be equal to three times the measure of the angle; and so on. Hence, if the arc which expresses the first position of the vernier plate be subtracted from that which expresses its last position, and the remainder, or, when the plate has made more than a complete revolution, the remainder increased by 360°, be divided by the number which denotes the number of times the operation has been performed, the quotient will be the angle required.

PROBLEM II.

To measure a vertical angle with the Theodolite.

The instrument being placed and levelled, direct the upper telescope to the point, of which the angle of elevation or depression is to be taken. Then, if the vernier of the vertical limb is accurately adjusted, the angle indicated by it will be the angle required. When this is not known to be the case, after having noted the arc indicated by the vernier, move the vertical limb till the telescope is horizontal, as indicated by the bubble of its level standing in the middle of the tube, and note the arc then indicated by the vernier. If in both positions the zero of the limb is on the same side as the zero of the vernier, subtract one arc from the other; but if on different sides, add the two arcs together. The result will be the required angle.

PROBLEM III.

To measure with the Theodolite, the angles of a tract of land, as ABCDEFGHA, Fig. 110; and having these and the measures of the sides, to find the content.

Set up the instrument at one of the angles as A, and also set up sight poles at H and B, or at some distant points in the sides AH and AB, and then measure the angle as directed in Prob. I. Proceed in the same way to measure the other angles of the tract, observing that the angle H, which is called a *re-entrant* angle, is to be regarded as measured by the arc *abc*, and is therefore greater than 180°.

When there are fences or other obstructions along the sides, the instrument must be set up at some distance from the corner, and the poles must be placed respectively as far from each side as the instrument is from the range of that side, so that straight lines from the instrument to the poles, may be parallel to the sides.

With the theodolite, or, which is better, with a compass, take the bearing of one of the sides, as AH. With this bearing and the angle A, find the bearing of AB. Then with the bearing of BA, which is the reverse of the bearing of AB, and the angle B, find the bearing of BC; and proceed thus, to find the bearings of the other sides.

Having measured the horizontal lengths of the sides, and obtained the bearings from the measured angles, the content may be found by prob. 12, chap. III.; observing that as the differences of latitude and the departures are given in the traverse table, only for every quarter of a degree, they should be computed for each side by prob. 10, chap. I.; or, if they are taken from the traverse table, proportional parts should be applied for the odd minutes, above full quarters of a degree.

Note 1. When the angles of the tract have all been measured, the accuracy of the measures may be tested as follows. Subtract 2 from the number of sides of the tract, and multiply 180° by the remainder; the product will express the sum of all the interior angles (32. 3. cor. 1.) Hence if the sum of the measured angles is equal, or very nearly equal, to this sum, they may be regarded as having been correctly taken; but should the sums differ considerably, an error in one or more of the angles must have been committed, and the operations should be repeated.

2. In measuring the lengths of the sides, if any of them have a considerable ascent or descent, and if

this ascent or descent is tolerably regular, it will be more convenient to measure their real lengths along the ground, and then by the theodolite determine for each of them the quantity that must be subtracted in order to obtain the horizontal lengths. To do this, let a mark be made on the pole at the farther end of the line, at the same height from the ground as the axis of the vertical limb of the theodolite, and direct the upper telescope to this mark. The index to that arc of the vertical limb, which is graduated for the purpose, will then indicate the number of links which must be subtracted from each chain in the measured length, to obtain the horizontal length.

3. Instead of measuring all the sides and angles, we may take two or three or more stations within the tract, and apply the method given in the 13th problem of chap. III. The stations should be so chosen that none of the angles contained between the lines which connect any two of the stations with a corner of the tract, should be either very acute or very obtuse. When the stations are judiciously chosen, their horizontal distances accurately measured, and the requisite angles, contained between the lines joining the stations with one another and with the corners of the tract, are carefully taken with a good theodolite, the content may in this way be very correctly determined. We may also, if it is required, compute the sides and angles of the tract; and thence, if the bearing of one of the sides or of one of the lines joining a station with a corner, has been taken, the bearings of all the sides may be obtained.

PROBLEM IV.

To run a line with the Theodolite from one end B, of a given line AB, Fig. 118, *that shall make a given angle with that line.*

Let the theodolite be placed at B and levelled. Then, a sight-pole being set up at A, direct the telescopes to it and note the arc indicated by the verniers. Add the given angle to this arc, and turn the vernier plate till the arc indicated by its verniers is equal to the sum, and clamp it in that position. Look through the lower telescope to ascertain whether the graduated plate has changed its position, and if it has, bring it back by the tangent-screw F. If the upper telescope is not nearly parallel with the ground in the direction in which it points, make it so, by turning the milled head N, and then let a sight-pole be set up at some distant point exactly in the direction of the line of collimation. Suppose C to be such a point. Then will BC be the required line. This line may be, if desired, marked by driving a number of stakes into the ground at convenient distances along it, using the telescope to have them accurately placed.

If it is required to extend the line beyond the point C, let a sight-pole be set up at B, and the theodolite be removed to C. Then proceed to set up a pole at an other point D, exactly as directed above, except that the given angle must now be considered as being 180°, in order that CD may be in the same direction with BC. Or, after having directed the telescope to the pole at B, we may, instead of turning the vernier plate 180°, let it remain unmoved, and reverse the telescope in its Y's, which will amount to the same. Proceeding thus from point to point, we may extend the line to any required distance.

CHAPTER VIII.

LEVELLING.

The surface of an expanse of tranquil water or any similar surface concentric with it, is called a *Level Surface.* Any points situated in a level surface are said to be on the *same level;* and any line traced in such a surface is called a *line of level.*

If through any place, a level surface be conceived to pass, the distance which another place is from this surface, either above or below, measured on a line perpendicular to it, is called the *difference of level* of the two places.

Levelling is the art of determining the difference or differences of level of two or more places.

In consequence of the globular figure of the earth, a level surface is not, as it appears to be, a plane surface. It is nearly, though not exactly, spherical. In the operations of levelling we may, without sensible error, regard a level surface at any place, as being strictly a spherical surface, with a radius equal to 3956 miles, the mean radius of the earth, or, which is more exact, with a radius equal to 3968 miles;* the centre being in a straight line conceived to be drawn downwards from the place, perpendicular to the level surface. And for places not very remote from each other, we may regard the spherical surfaces of level passing through them, as having a common centre.

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* The earth, if we disregard the inequalities in its surface, is an oblate spheroid. Its polar diameter is 7899 miles, and its equatorial diameter 7925 miles. A level surface is therefore a spheroidal surface. The radius of the spherical surface which most nearly coincides with any small portion of this spheroidal surface, changes slightly with the latitude of the place. For any place in the United States, the greatest error which can occur from

Let A and B, Fig. 120, be two places, not very remote from each other, and C, the common centre of the spherical surfaces of level passing through them. With the centre C and radius CA, describe the arc A*a*. Then will A*a* be a line of level of the place A, and B*a* will be the difference of level of the two places A and B.

The line A*d*, drawn perpendicular to CA, is called a line of *apparent level* of the place A. It is the line of level that would be indicated by an accurately adjusted levelling instrument placed at A. The distance *ad* is called the *correction of the apparent level.* This correction must be *subtracted* from the height B*d* of the apparent level to obtain the height B*a*, of the true level. The correction varies as the square of the distance from the place.* The following table contains the

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considering the level surface passing through it, as a spherical surface with a radius equal to the mean radius of the earth, is about $\frac{1}{3}$ of an inch for a distance of two miles. For a spherical surface with a radius 5 or 6 miles greater than the equatorial radius of the earth, the greatest error is about $\frac{1}{16}$ of an inch, at the same distance. It may be further observed, that the greatest error or greatest deviation of the spherical from the spheroidal surface, varies as the square of the distance from the place.

* We have (36.3), $(2\mathrm{C}a + ad)$, $ad = \mathrm{A}d^2$. But as ad, for any distance to which a single sight in levelling is ever extended, is extremely small in comparison with $2\mathrm{C}a$, we may, without sensible error, take $2\mathrm{C}a$ instead of $(2\mathrm{C}a + ad)$. We shall thus have $2\mathrm{C}a$, $ad = \mathrm{A}d^2$; or $ad = \frac{\mathrm{A}d^2}{2\mathrm{C}a}$. Consequently as C*a* is constant, *ad* varies as the square of the distance A*d* varies.

Let the value of *ad* be required for a distance of 100 chains or 6600 feet. Then taking $\mathrm{C}a = 3968$ miles, we have $2\mathrm{C}a = 7936$ miles $= 7936 \times 5280$

value of the correction in decimal parts of a foot, for each chain of distance, from 1 to 120.

TABLE,

Giving the differences between the true and apparent level, for distances from 1 *to* 120 *chains.*

Chains.	Feet.	Chains.	Feet.	Chains.	Feet.	Chains.	Feet.	Chains.	Feet.
1	.000	25	.065	49	.250	73	.554	97	.978
2	.000	26	.070	50	.260	74	.569	98	.998
3	.001	27	.076	51	.270	75	.585	99	1.019
4	.002	28	.082	52	.281	76	.600	100	1.040
5	.003	29	.087	53	.292	77	.616	101	1.060
6	.004	30	.094	54	.303	78	.632	102	1.082
7	.005	31	.100	55	.314	79	.649	103	1.103
8	.007	32	.106	56	.326	80	.665	104	1.124
9	.008	33	.113	57	.338	81	.682	105	1.146
10	.010	34	.120	58	.350	82	.699	106	1.168
11	.013	35	.127	59	.362	83	.716	107	1.190
12	.015	36	.135	60	.374	84	.734	108	1.213
13	.018	37	.142	61	.387	85	.751	109	1.235
14	.020	38	.150	62	.400	86	.769	110	1.258
15	.023	39	.158	63	.413	87	.787	111	1.281
16	.027	40	.166	64	.426	88	.805	112	1.304
17	.030	41	.175	65	.439	89	.823	113	1.327
18	.034	42	.183	66	.453	90	.842	114	1.351
19	.038	43	.192	67	.467	91	.861	115	1.375
20	.042	44	.201	68	.481	92	.880	116	1.399
21	.046	45	.211	69	.495	93	.899	117	1.423
22	.050	46	.220	70	.509	94	.919	118	1.447
23	.055	47	.230	71	.524	95	.938	119	1.472
24	.060	48	.240	72	.539	96	.958	120	1.497

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feet. Hence $ad = \frac{6600^2}{7936 \times 5280} = \frac{100^2 \times 66^2}{7936 \times 5280} = \frac{100^2 \times 66}{7936 \times 80} = 1.0396$ ft. Having the correction for 100 chains, we easily obtain it for any other distance by the following proportion: As 100^2 : square of given distance in chains : : 1.0396 : the required correction, in feet.

When a ray of light passes obliquely through portions of air of different densities, it becomes bent from a straight line, and enters the eye so as to make the point from which it proceeds appear in a direction slightly different from its true direction. This effect is called *Refraction;* and when the point, or body from which the light proceeds, is on or near the earth, it is called *Terrestrial Refraction.* Terrestrial Refraction generally makes the point appear to be more elevated than it really is. Thus it is not actually the point *d* of the line CE, Fig. 120, that, to an eye at A, appears to be at *d*, but another point *c*, a little below *d*. If therefore we wish to notice the effect of refraction, we must take *ac* instead of *ad*, for the correction of apparent level. In temperate climates, *cd* is, in the usual state of the atmosphere, about $\frac{1}{6}$ of *ad*. Consequently we may obtain the correction of apparent level with allowance for refraction, by diminishing the correction given in the preceding table by a $\frac{1}{6}$ part.

As the effect of refraction in the common operations of levelling is always small, and is subject to considerable variations depending on the state of the air between the object and place of observation, it is commonly disregarded. It would, however, in general be better to allow for it as above, except when the object is but little distant from the place of observation, or when, by the method noticed in the next article, the desired result is obtained independently of the correction of apparent level.

Let CD, Fig. 121, be the line of apparent level indicated by a levelling instrument L, placed midway between the places A and B; also let the arc *bc* be the line of true level passing through the instrument, the arc A*a*, concentric with the former, the line of true level of the place A, and AC and BD, lines perpendicular to A*a*. Then in consequence of the equality of the distances LC and LD, we have *b*C equal to *c*D; and therefore as A*b* is equal to *ac*, we have AC equal to *a*D. Consequently B*a*, the difference of level of the places A and B, is obtained by subtracting AC, the height of the apparent level of the instrument, at A, from BD, its height at B. We thus obtain the difference of level of the two places, independently of the correction of apparent level. It is also independent of refraction, as the effect of refraction would be sensibly the same for the two points C and D, and in the same direction. It may be observed that it is not necessary the instrument should be directly between the places. It may be placed in any convenient position on either side of the line joining them, provided its distances from the places are equal, or very nearly so.

OF THE LEVELLING INSTRUMENT.

The *Levelling Instrument*, or *Level* as it is frequently called, is an instrument used to denote the line of apparent level. It is supported, like the theodolite, on a tripod. The instrument, without the tripod, is represented in Fig. 119. Its lower part is nearly similar to the corresponding part of the theodolite. The plate HH, which screws on the tripod, has four levelling-screws inserted in it, by means of which the plate GG may be placed in a horizontal position, even when the former is considerably inclined. S is a clamp-screw and O a tangent-screw. The bar EE is firmly attached at right angles to an axis, which terminates in a ball, enclosed in the socket R. In some instruments this bar is enlarged at the middle so as to form a compass box, in which a magnetic needle is placed. The telescope AB is supported on two wyes, Y1 and Y2, one of which, Y1, is firmly connected with the bar EE, and the other, Y2, is moveable a small distance up or down by the screw N, or in some instruments by two screws, M and P. The eye-tube L is moveable in or out by hand, so as to render the spider's lines distinctly visible, and the tube which contains the object-glass is moved by turning the milled head *d*, and may thus be so adjusted as to give distinct vision of an object to which the telescope is directed. One end, C, of the spirit-level CD is moveable up or down by the screw *m*, and the other end is moveable laterally by two opposite screws *p* and *q*, of which only *p* appears in the figure.

The following adjustments of the level should be examined, and corrected if necessary, before using it in practical operations.

FIRST ADJUSTMENT.

To make the line of collimation coincide with the axis of the telescope.

Having screwed the level to the tripod and set up the instrument so as to stand firmly, loosen the clamp-screw, turn the telescope towards some distant well-defined object, and fasten the screw. By means of the tangent-screw move the telescope slowly till the line of collimation is directed exactly to some distinct point in the object, and then proceed according to the instructions in the second paragraph of the first adjustment of the theodolite.

SECOND ADJUSTMENT.

To make the axis of the level CD parallel to the line of collimation.

By turning the screw N, bring the bubble of the level to stand at the middle of the tube. Reverse the telescope in its wyes, and, if the bubble does not then stand in the middle, correct one half of the deviation by the screw *m*, and the other half by the screw N. Again reverse the telescope in its wyes, and repeat the correction if necessary.

Now by revolving the telescope in its wyes, bring the level to some distance on one side of its lowest or proper position, and if the bubble then deviates from the middle, the deviation must be corrected by means of the screws *p* and *q*, which move one end of the level laterally, the correction being continued till the bubble will remain at the middle while the telescope is revolved so as to bring the level to a considerable distance on either side of its lowest position. When this has been done, the first part of the adjustment should again be examined and corrected if necessary.*

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* A method by which the second adjustment may be made for an instrument in which the telescope is not reversible, will be found in the first of the following problems.

THIRD ADJUSTMENT.

To make the line of collimation parallel to the bar EE, or which is the same, at right angles to its axis.

Turn the telescope till it stands directly over two of the levelling-screws, and by means of them bring the bubble to stand at the middle of the tube. Then turn the telescope half round, that is, till it stands over the same screws, but pointing in the opposite direction, and if the bubble does not remain in the middle, correct one half of the deviation by the levelling-screws and the other half by the screw N. Now place the telescope over the other levelling-screws, and proceed in a similar manner. Continue the corrections till the bubble will remain in the middle of the tube during an entire revolution.

These adjustments having been carefully made, the instrument is ready for use. When on the ground it must, in each new position in which it is placed, be *levelled.* This is done by placing the telescope over two of the levelling-screws and by their means bringing the bubble of the level to the middle of the tube, then doing the same with the telescope over the other two, and again over the first two. Then, if the third adjustment has been accurately made, the bubble will stand in the middle of the tube in any position of the telescope.

OF THE LEVELLING STAFF.

A *Levelling Staff* consists of a square or rectangular staff and a small circular or rectangular board, called a *Vane*, which is so attached to the staff as to be moveable along it from end to end. It is used for measuring the height of the line of apparent level passing through the telescope of the levelling instrument, above the place where the staff is placed.

The face of the vane, represented in Fig. 111, is divided into four equal parts by two straight lines intersecting each other at right angles; one line being horizontal, and consequently the other vertical. Two opposite parts of the face are painted white and the other two black; thus the lines and their intersection are easily distinguished even at a considerable distance. A screw, the head of which is shown at *m*, serves to clamp the vane to the staff in any required position.

The staff is composed of two rectangular bars of wood, between five and six feet long, placed side by side, and forming together a square staff, the breadth of each side of which is about an inch and a quarter. The bars are so connected that one, which is two or three inches the shorter of the two, may be made to slide along the other or principal bar, and thus, when necessary, increase the length of the staff. In order to this, the front or sliding bar has throughout its length, on the side next the other, a projection which is terminated by a brass plate a little wider than the projection and firmly attached to it; and the principal bar has a groove in it to receive the projection and plate of the former. The forms of the projection and groove are exhibited in Fig. 112, which represents a section of the bars, at right angles to their length.

The staff is represented in Fig. 113, in which *bcefd* is the principal bar, which is capped at the bottom with a brass plate; *bd* is the sliding bar, A is the vane, seen edgewise, and *n* is a screw which serves to clamp the bars together in any given position. One side of each bar is divided, from *bg* upwards, into feet and hundredths of a foot; the feet being numbered as in the figure. The subdivisions of the feet are omitted as they could not well be all exhibited. On the chamfered edge of a brass plate connected with the vane, a fine line *a* is drawn, directly opposite to the horizontal line of the vane. The line *a* serves therefore to denote on the side of the principal bar, the height that the vane is above the line *bg*, when that height does not exceed 5 feet.

The height of the vane above the line *bg* is usually called the *height of the vane*, although it is less than its true height above the ground or place on which the staff stands, by the length of the part *bc*. This however produces no error in the use of the staff in levelling, as the difference in level of two places is found from the difference in the heights at the places, of a line of apparent level passing through the levelling instrument, and this difference will evidently be the same whether both heights are measured from the ground, or both from the line *bg*.

When it is required to raise the vane to a greater height than 5 feet, it must be slid up to a pin at *p*, which checks it at that height, and be fastened there by the screw *m*, Fig. 111. Then loosening the screw *n*, Fig. 114, the front bar, which carries the vane, may be slid upwards till the vane acquires the required height When this is done, that point on the graduated side of the sliding bar, which corresponds to the line marked 5, on the principal bar, will evidently indicate the height of the vane.

SCHOLIUM.

The theodolite, levelling-instrument, and levelling-staff, are made of various forms and of different degrees of perfection. Those which have been described are, when well made, good and convenient instruments; and from the descriptions which have been given of them, the student will find it easy to understand the manner of adjusting and using others which may differ from them in form.

PROBLEM I.

To test the adjustment of the level.

Select a place where the ground is tolerably level for a distance of 15 or 20 chains, and at each extremity of the distance chosen, as at A and B, Fig. 122, drive a short stake. Set up the level by the stake at A, placing it so that the eye-end of the telescope may be over or nearly over the stake, and level the instrument. Place the levelling-staff on the stake, raising or lowering the vane till its horizontal line is at exactly the same height as the centre of the eye-end of the telescope, and note the height. Now let an assistant take the staff and set it up vertically on the stake at B. Direct the telescope to the middle of the breadth of the staff, and then, by raising or lowering the hand as a signal, direct the staff-bearer to raise or lower the vane, repeating the signal till its centre appears precisely in the direction of the line of collimation, or at least exactly of the same height. When this is the case, by a circular motion of the hand, direct the vane to be clamped, and again sight to it to ascertain that in clamping, its height has not been changed. Note the height of the vane, and subtract from it the correction of apparent level corresponding to the distance between the stakes, taken from the preceding table, or rather this correction diminished by a $\frac{1}{6}$ part, to allow for refraction. Then, if the instrument is accurately adjusted and the observations have been carefully made, the difference between the height of the vane at A, and its corrected height at B, will be the true difference of level of the tops of the two stakes; the higher being that at which the height of the vane is the less. Placing now the instrument at B, proceed in the same manner to find again the difference of level of the stakes. If this difference is the same as the former, the adjustment of the instrument is correct. But if there is any material difference in the two results, we infer that the axis of the level is not parallel to the line of collimation. To make it so, take half the difference of the results obtained, and let the vane, taken in its last position, be *elevated* or *depressed* by that quantity, according as the result obtained at the more elevated of the two stakes, is *less* or *greater* than that obtained at the other.* Then, by the screw N, bring the line of collimation to point exactly to the horizontal line of the vane, and with the telescope in that position, bring the bubble again to the middle of the tube by the screw *m*.

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* Let *ab* be the line of apparent level through the instrument when placed at A, and *ae*, the line of apparent level indicated by the instrument. Then *cd* being the line of apparent level through the instrument when placed at B, the line *cf* making the angle *f*L*d* equal to *b*L*e*, and consequently *df* equal to *be*, will be the line of apparent level indicated by the instrument.

Note. In this manner the axis of the level may be made parallel to the line of collimation when the telescope is not reversible, as is the case in some instruments.

EXAMPLE.

Let the height A*a*, be 5.295ft.;* B*e*, 2.063ft.; B*c*, 5.527ft.; and A*f*, 8.935ft.; and the horizontal distance from A to B, 20 chains.

The distance being 20 chains, the correction for apparent level, taken from the table, is 0.042ft. From this deducting $\frac{1}{6}$ of 0.042, we have 0.035ft. for the correction to be subtracted from the heights B*e* and A*f*. This gives, for the corrected heights, B*e* = 2.028ft., and A*f* = 8.900ft. Hence, taking 2.028 from 5.295, we have 3.227ft. for the true difference of level obtained with the instrument at A; the place B being higher than A. And taking 5.527 from 8.900, we have 3.373ft. for the difference of level obtained with the instrument at B. Half the difference of these results gives 0.053ft. for the value of *df*, the error due to the error in the

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It is therefore evident that the difference of level of the two places obtained with the instrument at A, is less than the true difference by the quantity *be*, and the difference obtained with the instrument at B, is greater than the true difference, by the equal quantity *df*. Hence the difference of the two results must be twice *df*, the error in height produced by the error in the adjustment of the instrument.

* Although the station staff is only divided to hundredths of a foot, we may with tolerable precision estimate the thousandths; and when great accuracy is desired, it is better to do so.

adjustment of the instrument. Hence, as the difference of level given by the instrument at the more elevated place is greater than the other, the vane must be lowered 0.053ft. from its last height. The adjustment may then be made as directed.

PROBLEM II.

To determine the difference of level of two places, A and B, Fig. 123, *when they are visible from each other and do not differ in level more than* 8 *or* 10 *feet.*

Place the level in some position C, about equally distant from the places, either in the line joining them or on either side as may be most convenient, and level the instrument. Let the staff-bearer set up the levelling-staff at A, and having sighted to it and obtained the height of the vane at that station, let the staff be removed to B, and do the same. Then the difference of the two heights, without any corrections, will be the difference of level of the places; that place being the higher, at which the height of the vane is the less.

If the surface of the ground between the places is such that when the level is placed at equal or nearly equal distances from them, the line of apparent level of the instrument would pass below one place or too high above the other, as in Fig. 124, it may be placed in any position C, that will permit the sights to be taken to both places. Then, having measured the horizontal distances from A to C, and from C to B, we proceed as above, except that the observed heights A*a* and B*b* must be corrected by the differences between the true and apparent level, as taken from the table;

or, which is generally better, by the tabular quantities diminished by a $\frac{1}{6}$ part. It may, however, be observed that when neither of the distances AC nor BC, exceeds five or six chains, the corrections are so small that they may be generally omitted.

When a valley intervenes between the two places so that there is no suitable intermediate situation for the instrument, it may be placed at one of them; and then the difference of level may be determined as in the preceding problem.

EXAMPLES.

1. Let the observed height A*a*, Fig. 123, be 7.343ft. and B*b*, 3.635ft.; then the difference of these, 3.708ft. is the difference of level of A and B, the place B being higher than A.

2. Let the observed height A*a*, Fig. 124, be 8.457ft.; B*b*, 1.525ft.; the distance from A to C, 24.1ch.; and the distance from C to B, 8.2ch.

The correction for the distance 24.1ch., taken from the table and diminished by a $\frac{1}{6}$ part, is 0.050ft., and for the distance 8.2ch., it is 0.006ft. The corrected heights are therefore A*a*, 8.407ft. and B*b*, 1.519ft. Hence the difference of level is 6.888ft.

PROBLEM III.

To find the difference of level of two places not visible from each other, or if visible, differing considerably in level.

Let A and F, Fig. 125, be the two places. Place the level in some position P, that will permit a sight to be taken to A, and also to some other place towards F, at about the same distance from the instrument. Hàving levelled the instrument, let the staff-bearer set up the staff at A, and when the sight has been taken, let him note the height of the vane as a first *back-sight.* Then let the staff be taken to some station B, about as far from the instrument as that is from the station A, and when the sight has been taken, let the height of the vane be noted as the first *fore-sight.* Next, the staff-bearer remaining at B, take the level to some suitable place Q, beyond B, and proceed to take a back-sight to B, and then a fore-sight to a new station C. In the same manner the operation must be continued from C to D, from D to E, and from E to F; the number of intermediate stations necessary to be taken, depending on the irregularities in the ground and on the difference of level of the given places.

Take the difference between the sum of the back-sights and the sum of the fore-sights, and it will be the difference of level of E and F; the place F being *higher* or *lower* than A, according as the sum of the back-sights is *greater* or *less* than that of the fore-sights.[*]

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[*] Let GF be a line of level through the place F; then AG is the difference of level of the two places A and F. Now we have,

Sum of back-sights,

$$= \mathrm{A}a+\mathrm{B}c+\mathrm{C}e+\mathrm{D}g+\mathrm{E}l = \mathrm{A}a+bc+\mathrm{B}b+\mathrm{C}e+\mathrm{D}g+\mathrm{E}l.$$

Also,

Sum of fore-sights,

$$= \mathrm{B}b+\mathrm{C}d+\mathrm{D}f+\mathrm{E}h+\mathrm{F}m = \mathrm{B}b+\mathrm{C}e+ed+\mathrm{D}g+gf+\mathrm{E}l+lh+\mathrm{F}$$
$$= \mathrm{F}m+lh+gf+ed+\mathrm{B}b+\mathrm{C}e+\mathrm{D}g+\mathrm{E}l = qd+\mathrm{B}b+\mathrm{C}e+\mathrm{D}g+\mathrm{E}l$$
$$= pc+\mathrm{B}b+\mathrm{C}e+\mathrm{D}g+\mathrm{E}l = \mathrm{AG}+\mathrm{A}a+bc+\mathrm{B}b+\mathrm{C}e+\mathrm{D}g+\mathrm{E}l.$$

The difference of these sums is AG, the difference of level of the places A and F.

Note. It is not necessary that either the intermediate stations or the places of the instrument should be in the direct line between the given places; and frequently it will be found convenient to deviate considerably from that line. It may further be observed that although it is generally best to take each pair of the sights at equal or nearly equal distances, as the correction for apparent level is thus avoided, and also a slight deviation of the axis of the level from parallelism with the line of collimation will not then sensibly affect the accuracy of the result, yet sometimes in order to diminish the number of stations the sights are taken at unequal distances. When this is done, the distances must be measured and the sights be corrected as directed in such case, in the last problem.

EXAMPLE.

Let the back-sights and fore-sights, Fig. 125, be as in the following table.

	Back-sights.	Fore-sights.
1.	7.103ft.	1.566ft.
2.	9.227	3.178
3.	1.236	9.415
4.	1.610	6.367
5.	2.125	9.910
	Sum 21.301	Sum 30.436
		21.301
		Diff. 9.135ft.

Hence the difference of level of A and F is 9.135ft. and as the sum of the back-sights is less than that of the fore-sights, the place F is lower than A.

CHAPTER IX.

TOPOGRAPHY.

Topography is a branch of surveying,* the object of which is to determine and designate on a map, the various undulations and inequalities in the surface of a particular place, tract of land or district of country. A map in which these inequalities, the courses of streams, and sometimes other circumstances, as the positions and extents of forests, marshes, &c., are designated, is called a *topographical map.*

In addition to the boundaries and content of a tract of land, it is frequently required that the various slopes and irregularities of the surface should be determined and designated, in order to give a more complete view of the ground, and to afford the means for an appropriate location of buildings or works of any kind that may be designed to be erected on it.

If we assume the surface of a tract of land to be intersected by a number of level surfaces or horizontal planes† at equal distances from one another, and transfer all the lines of level in which these planes meet the surface of the ground to an assumed horizontal plane passing through the lowest point, making them occupy positions on that plane, corresponding with their positions on their respective planes, the variations in the distances of the lines from one another, when thus transferred, will indicate the variations in the inclination of the ground. For as the difference of level from line to line is the same, it is evident that the horizontal distances of the lines, taken in any direction, will diminish as the inclination in that direction increases. Thus in ABCD, Fig. 129, which represents a small tract, of which the length AB is 1000 feet and the breadth AD, 800 feet, the lines 10, 20, 30, &c., represent lines of level in which horizontal planes at the distance of 10 feet from one another, intersect the surface of the ground. The lowest level passes through the point F, at which the stream EF leaves the tract. From F the ground rises more rapidly to the left than to the right, as is indicated by the lines of level being nearer to one another on that side than on the other. In passing from F towards the corner B of the tract, we may observe that the acclivity, which is gentle, increases till we come to the 30 feet level, then diminishes to the 40 feet level; it then again increases, and more rapidly, to the 60 feet level, and lastly slightly diminishes to the 70 feet, or highest level. In descending, the declivity continually diminishes to B. From the point *l* in the side AD, the ground descends moderately towards the corner A, the declivity diminishing till the surface becomes nearly level; and from the stream, towards A, the acclivity, which is slight, diminishes, so that between the two branches of the 30 feet line of level and the corner A, the ground is nearly level.

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* The term surveying is here used in a more extended sense than as defined in the first chapter.

† In tracts of any moderate extent, the surfaces of level may, for the purpose for which they are here introduced, be regarded as horizontal planes

The distance which should be taken for the distance of the assumed planes from one another, must depend on the extent of the survey, the inequalities in the surface, and the degree of minuteness with which it is required that they should be designated. It may vary from 3 or 4 to 20 or 30 feet, according to circumstances.

The levelling required for a topographical survey may be performed either with a level or theodolite. Where there is considerable ascent or descent in the ground, the latter is the most convenient instrument; and although the results obtained with it are not in general as accurate as those that may be obtained with a good level, they are, when due care is taken, sufficiently so for the object in view. When the theodolite is used, the sight should be taken to a point at the same height above the ground at the station, as the axis about which the upper telescope revolves is above the ground at the place of the instrument. To do this, let an assistant place and clamp the vane of a levelling-staff at that height, or make a mark at the same height on a pole; and when he has taken the staff or pole to the station and set it up vertically, sight to the vane or mark. When this is done, the difference of level between the station and place of the instrument, expressed in 100th parts of the horizontal distance of the two, will be indicated on the vertical limb. It is however better, except when the horizontal distance is quite small, to obtain the difference of level from that distance and the angle of elevation or depression.

PROBLEM I.

Having given the back-sights and fore-sights taken to a number of consecutive stations, or to two or more connected series of stations, to determine the heights of the stations above a line of level or surface of level through the lowest.

1. *When there is but one series of stations.* Assume for the height of the first station above some assumed line of level, any quantity taken at pleasure, observing however to make it sufficiently great for the assumed line of level to be lower than the lowest station, or at least as low. To the assumed height of the first station add the first back-sight, and from the sum subtract the first fore-sight, and the remainder will be the height of the second station above the assumed line of level. With this height and the second back-sight and second fore-sight proceed in like manner to find the height of the third station; and thus on to the last. Now subtract the least of the heights obtained, which must be that of the lowest station, from each of the others, and the remainders will be the heights of the other stations above the line of level passing through the lowest.

2. *When there are two series of stations connected by intervening sights between the first station of the first series and the first of the second series.* Assume for the height of the first station of the first series, a quantity sufficiently great for the assumed surface of level to be below all the stations, or at least as low as

the lowest, and proceed as directed above, to obtain the heights of the other stations of that series above the assumed surface of level. Then commencing again with the assumed height of the first station, proceed in like manner with the sights connecting that with the first station of the second series, and with the sights to the stations in this series, to find the heights of all these stations. When this is done, subtract the least of all the heights obtained from each of the others, and the remainders will be the required heights.

3. In like manner, whatever be the number of the series of stations, the heights of all the stations, above a surface of level passing through the lowest, may be obtained.

Note. If it is required to find the heights of the stations above a line or surface of level at a given distance below the lowest or any other given station, it is easily performed by applying to the heights of the stations above the assumed level, the difference between the height of that station above the assumed level and its height above the given level.

EXAMPLES.

1. Taking to the nearest length of a foot, the back-sights and fore-sights given in the example to the last problem of the preceding chapter, it is required to find the heights of the stations A, B, C, &c. Fig. 125, above a line of level passing through the lowest.

Assume the height AL, of the station A, above an assumed line of level LM to be 15 feet. Then we have

Feet.

15, height of A, above LM,
15 + 7.1 — 1.6 = 20.5 " B, "
20.5+9.2 — 3.2 = 26.5 " C, "
26.5+1.2 — 9.4 = 16.3 " D, "
16.3+1.6 — 6.4 = 11.5 " E, "
11.5+2.1 — 9.9 = 5.7 " F, "

Subtracting 5.7 from each of the above heights, we have the heights above GF, the line of level through F. These are, for A, 9.3ft.; B, 14.8ft.; C, 20.8ft.; D, 10.6ft.; E, 5.8ft.; and F, 0ft.

2. Let the back-sights and fore-sights, taken from A to B, Fig. 126, from A to C, and from C to D, be as given below; to find the heights of the stations along AB, AC, and CD, above a surface of level through the lowest station.

AB

	B-sts.	F-sts.
1	8.7ft.	3.8ft.
2	1.1	9.9
3	0.7	9.3
4	2.2	8.0
5	1.9	7.1
6	7.4	4.2

AC

	B-sts.	F-sts.
1	8.5ft.	5.2ft.
2	0.6	9.1

CD

	B-sts.	F-sts.
1	3.1ft.	8.6ft.
2	2.6	7.7
3	1.5	9.3
4	4.2	7.9
5	3.8	7.3
6	9.3	2.2
7	2.8	7.4

By proceeding as directed in the rule, we obtain the following heights of the stations above the surface of level passing through the lowest.

	AB
1	30.8ft.
2	35.7
3	26.9
4	18.3
5	12.5
6	7.3
7	10.5

	AC
1	30.8ft.
2	34.1
3	25.6

	CD
1	25.6ft.
2	20.1
3	15.0
4	7.2
5	3.5
6	0.0
7	7.1
8	2.5

PROBLEM II.

To determine the inequalities in the surface of the ground along a line running in a given direction, and to draw an irregular or curved line to represent them.

Let short stakes be driven at the beginning and end of the line, and at each point along it where there is any material change in the inclination of the ground; and let the horizontal distance of each stake from the beginning of the line, or the distances from stake to stake, be measured. Then level from stake to stake, using intermediate stations whenever the difference of level between any two is too great to permit sights to be taken to both from a single position of the instrument. Find, by the last problem, the heights of the stations, where the stakes are placed, above a line of level passing through the lowest, or above any assumed or given line of level.

Draw a straight line *ef*, Fig. 127, to represent the line of level to which the heights of the stations are referred, and on it make *ea*, *eb*, *es*, *ec*, &c., equal to the distances of the stations from the beginning of the line. From the points *e*, *a*, *b*, *s*, &c., draw lines perpendicular to *ef*, and make them equal to the heights of the respective stations. Through the tops of these perpendiculars, draw the curved line EF, which will be the line required to be drawn.

The line EF is called a *Profile* of the ground in the direction of the given line.

Note. The heights of the perpendiculars are frequently taken from a scale three or four times as great as that used in laying off the horizontal distances. When this is done, the curved line, or profile, as it is still called, indicates more distinctly the lesser changes in the inclination of the ground.

EXAMPLE.

The distances of the stations along a given line, measured from the beginning of the line, and their heights above a given line of level, determined by the last problem, from sights taken on the ground, being as below, the profile of the ground in the direction of the line, obtained by taking the heights from a scale three times as great as that from which the distances are taken, will be that of Fig. 127.

Sta.	Dist.	Ht.	Sta.	Dist.	Ht.
1	0ft.	41.1ft.	8	610ft.	41.9ft.
2	90	38.3	9	655	55.0
3	230	22.0	10	725	69.2
4	336str.	15.3	11	770	72.0
5	445	21.1	12	850	69.1
6	505	32.5	13	915	56.5
7	555	36.5	14	1000	50.1

At the fourth station a stream of water crosses the line, and is noted by the letters *str.* placed by the side of the distance.

PROBLEM III.

To determine those points along a line running in a given direction, that are at given heights above a given line or surface of level.

Proceed, as directed in the last problem, to find the heights above the given line or surface of level, of those points in the line where there is any material change in the inclination of the ground, and also their distances from the commencement of the line. Observe between which two of the heights obtained, any one of those given falls, and take their difference. Also take the difference between the given height and that one of the two which appertains to the point nearest the beginning of the line. Then, as the first difference : the second : : the horizontal distance between the points : to a fourth term, which added to the distance of the point nearest the beginning of the line, will give the distance of the required point.

Proceed in the same manner with the other given heights.

Or we may draw, by the last problem, a profile of the ground, as EF, Fig. 128, in reference to the given line of level *ef*, and on *ea*, perpendicular to *ef*, set off the given heights, taking them from the scale used in setting off the heights of the stations. Then, through the points in the line *ea*, draw lines parallel to *ef*, as in the figure; and from the points in which these meet the profile EF, draw lines parallel to *ea*. The distances from *e*, at which these last lines meet *ef*, will be the horizontal distances of the required points, from the beginning of the line.

EXAMPLE.

Let the data found on the ground be the same as in the example to the last problem, and let the given heights of the required points be 10, 20, 30, 40, &c. feet.

The distances and heights of the stations being the same as for the profile in Fig. 127, we shall obtain a similar profile EF, Fig. 128. Drawing the lines parallel to *ef* at distances from it, equal to 10, 20, 30, &c. feet, we find that the first line above *ef* does not meet the profile EF. Consequently there is no point in the latter so low as 10 feet above the given level. Each of the other parallels meets the line EF in two points. There are therefore two points in the line at the height of 20 feet above the given level; two at the height of 30 feet; and so on to 70 feet. The distances *e*, 40; *e*, 30; &c., on the line *ef*, are the distances of the required points from the beginning of the line.

In illustration of the first method of finding the distances of the required points from the beginning of the line, as the given heights of the stations evidently show that there is no point in the line so low as 10 feet above the given level, let it be required to find a point at the height of 20 feet. On examining the given heights of the stations, we perceive that there must be two such points; one between the 3d and

4th stations, and one between the 4th and 5th. For the first of these we take the difference between 15.3 and 22.0, which is 6.7; the difference between 20.0 and 22.0, which is 2.0; and the difference between the distances 230 and 336, which is 106. Hence, as 6.7 : 2.0 :: 106 : 32. Adding therefore 32 to 230, we have 262 feet for the distance of this point.

PROBLEM IV.

To determine the undulations and inequalities of the surface in a tract of land ABCD, Fig. 129, *and to draw a topographical map designating them.*

With a compass or theodolite, run a number of lines, *ab*, *cd*, *ef*, &c. across the tract, parallel to one of the sides, as AB; making them nearer together or farther apart, according to the inequalities in the ground and the degree of minuteness with which it is intended to designate them. Drive stakes at the beginnings and ends of the lines AB, *ab*, *cd*, &c., and at all the points along them where there is any material change in the inclination of the ground, and proceed to level from stake to stake along these lines and the line AC; also measure the distances of the stakes from the commencement of the lines, or from one another. Then, by problem I., find the heights of all the stations where the stakes are driven, above a surface of level passing through the lowest station.

Now, having drawn the lines *ab*, *cd*, *ef*, &c. in their proper positions on the map, determine, by the last problem, the points in these lines and the lines AB and DC, that correspond to heights in the lines on the ground, of 10, 20, 30, 40, &c. feet, above the surface of level passing through the lowest station, or to any other heights, increasing by equal differences, that may be deemed expedient. Through each set of points appertaining to the same height, draw a curve line. The curve lines thus drawn will represent lines of level of 10 feet, 20 feet, &c., or of the number of feet, of the heights used in obtaining them, whatever that may be.

These lines serve to indicate the changes in the inclination of the ground. But it is usual, instead of drawing them distinctly with ink, to draw them with a pencil only, or faintly with Indian-ink, and then to shade the map by short straight lines, drawn perpendicularly from each curve of higher level, to that of the next lower; the lines being drawn closer together and rather heavier as the distance between the lines of level diminishes. For those parts of the ground that are level, or very nearly so, the shading is omitted. The greater or less darkness of the shading on the different parts of the map, therefore indicates a greater or less inclination in the ground in those parts; and the omission of the shading in any parts, indicates that in those places the surface is level, or very nearly so. In Fig. 130, we have a map of the tract, shaded as described above.

Note. It is not necessary that the lines on which the levels are taken should be run parallel to one another. They may be run making given angles with any given lines of the survey. Sometimes it is desired that the surface of a particular part of the tract should be designated with more minuteness than is important for other remote parts. In this case it will be found convenient to determine the position of some point near the middle of the part which it is desired particularly to designate, and then to run lines from this point, in directions making angles of 20° or 30° with one another.

It may be further remarked, that instead of taking the surface of level through the lowest point, as the plane of reference, we may, if preferred, take that through the highest. The former is however the one generally taken.

The operations to be performed in this problem, so far as observations on the ground and numbers are concerned, are merely repetitions of those which have been exemplified in the preceding problems. An example is not therefore necessary.

THE END.

MATHEMATICAL TABLES:

DIFFERENCE

OF

LATITUDE AND DEPARTURE;

LOGARITHMS,

FROM 1 TO 10,000;

AND

ARTIFICIAL SINES, TANGENTS, AND
SECANTS.

STEREOTYPE EDITION, CAREFULLY REVISED AND CORRECTED.

Philadelphia:
PUBLISHED BY KIMBER AND SHARPLESS,
NO. 50, N. FOURTH-STREET.
1841.
....
Stereotyped by J. Howe, New-York.

Distance.	¼ Deg.		½ Deg.		¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.00	1.00	0.01	1.00	0.01	1
2	2.00	0.01	2.00	0.02	2.00	0.03	2
3	3.00	0.01	3.00	0.03	3.00	0.04	3
4	4.00	0.02	4.00	0.03	4.00	0.05	4
5	5.00	0.02	5.00	0.04	5.00	0.07	5
6	6.00	0.03	6.00	0.05	6.00	0.08	6
7	7.00	0.03	7.00	0.06	7.00	0.09	7
8	8.00	0.03	8.00	0.07	8.00	0.10	8
9	9.00	0.04	9.00	0.08	9.00	0.12	9
10	10.00	0.04	10.00	0.09	10.00	0.13	10
11	11.00	0.05	11.00	0.10	11.00	0.14	11
12	12.00	0.05	12.00	0.10	12.00	0.16	12
13	13.00	0.06	13.00	0.11	13.00	0.17	13
14	14.00	0.06	14.00	0.12	14.00	0.18	14
15	15.00	0.07	15.00	0.13	15.00	0.20	15
16	16.00	0.07	16.00	0.14	16.00	0.21	16
17	17.00	0.07	17.00	0.15	17.00	0.22	17
18	18.00	0.08	18.00	0.16	18.00	0.24	18
19	19.00	0.08	19.00	0.17	19.00	0.25	19
20	20.00	0.09	20.00	0.17	20.00	0.26	20
21	21.00	0.09	21.00	0.18	21.00	0.27	21
22	22.00	0.10	22.00	0.19	22.00	0.29	22
23	23.00	0.10	23.00	0.20	23.00	0.30	23
24	24.00	0.10	24.00	0.21	24.00	0.31	24
25	25.00	0.11	25.00	0.22	25.00	0.33	25
26	26.00	0.11	26.00	0.23	26.00	0.34	26
27	27.00	0.12	27.00	0.24	27.00	0.35	27
28	28.00	0.12	28.00	0.24	28.00	0.37	28
29	29.00	0.13	29.00	0.25	29.00	0.38	29
30	30.00	0.13	30.00	0.26	30.00	0.39	30
31	31.00	0.14	31.00	0.27	31.00	0.41	31
32	32.00	0.14	32.00	0.28	32.00	0.42	32
33	33.00	0.14	33.00	0.29	33.00	0.43	33
34	34.00	0.15	34.00	0.30	34.00	0.45	34
35	35.00	0.15	35.00	0.31	35.00	0.46	35
36	36.00	0.16	36.00	0.31	36.00	0.47	36
37	37.00	0.16	37.00	0.32	37.00	0.48	37
38	38.00	0.17	38.00	0.33	38.00	0.50	38
39	39.00	0.17	39.00	0.34	39.00	0.51	39
40	40.00	0.17	40.00	0.35	40.00	0.52	40
41	41.00	0.18	41.00	0.36	41.00	0.54	41
42	42.00	0.18	42.00	0.37	42.00	0.55	42
43	43.00	0.19	43.00	0.38	43.00	0.56	43
44	44.00	0.19	44.00	0.38	44.00	0.58	44
45	45.00	0.20	45.00	0.39	45.00	0.59	45
46	46.00	0.20	46.00	0.40	46.00	0.60	46
47	47.00	0.21	47.00	0.41	47.00	0.62	47
48	48.00	0.21	48.00	0.42	48.00	0.63	48
49	49.00	0.21	49.00	0.43	49.00	0.64	49
50	50.00	0.22	50.00	0.44	50.00	0.65	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	89¾ Deg.		89½ Deg.		89¼ Deg.		

Distance.	¼ Deg.		½ Deg.		¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	51.00	0.22	51.00	0.45	51.00	0.67	51
52	52.00	0.23	52.00	0.45	52.00	0.68	52
53	53.00	0.23	53.00	0.46	53.00	0.69	53
54	54.00	0.24	54.00	0.47	54.00	0.71	54
55	55.00	0.24	55.00	0.48	55.00	0.72	55
56	56.00	0.24	56.00	0.49	56.00	0.73	56
57	57.00	0.25	57.00	0.50	57.00	0.75	57
58	58.00	0.25	58.00	0.51	57.99	0.76	58
59	59.00	0.26	59.00	0.51	58.99	0.77	59
60	60.00	0.26	60.00	0.52	59.99	0.79	60
61	61.00	0.27	61.00	0.53	60.99	0.80	61
62	62.00	0.27	62.00	0.54	61.99	0.81	62
63	63.00	0.27	63.00	0.55	62.99	0.82	63
64	64.00	0.28	64.00	0.56	63.99	0.84	64
65	65.00	0.28	65.00	0.57	64.99	0.85	65
66	66.00	0.29	66.00	0.58	65.99	0.86	66
67	67.00	0.29	67.00	0.58	66.99	0.88	67
68	68.00	0.30	68.00	0.59	67.99	0.89	68
69	69.00	0.30	69.00	0.60	68.99	0.90	69
70	70.00	0.31	70.00	0.61	69.99	0.92	70
71	71.00	0.31	71.00	0.62	70.99	0.93	71
72	72.00	0.31	72.00	0.63	71.99	0.94	72
73	73.00	0.32	73.00	0.64	72.99	0.96	73
74	74.00	0.32	74.00	0.65	73.99	0.97	74
75	75.00	0.33	75.00	0.65	74.99	0.98	75
76	76.00	0.33	76.00	0.66	75.99	0.99	76
77	77.00	0.34	77.00	0.67	76.99	1.01	77
78	78.00	0.34	78.00	0.68	77.99	1.02	78
79	79.00	0.34	79.00	0.69	78.99	1.03	79
80	80.00	0.35	80.00	0.70	79.99	1.05	80
81	81.00	0.35	81.00	0.71	80.99	1.06	81
82	82.00	0.36	82.00	0.72	81.99	1.07	82
83	83.00	0.36	83.00	0.72	82.99	1.09	83
84	84.00	0.37	84.00	0.73	83.99	1.10	84
85	85.00	0.37	85.00	0.74	84.99	1.11	85
86	86.00	0.38	86.00	0.75	85.99	1.13	86
87	87.00	0.38	87.00	0.76	86.99	1.14	87
88	88.00	0.38	88.00	0.77	87.99	1.15	88
89	89.00	0.39	89.00	0.78	88.99	1.16	89
90	90.00	0.39	90.00	0.79	89.99	1.18	90
91	91.00	0.40	91.00	0.79	90.99	1.19	91
92	92.00	0.40	92.00	0.80	91.99	1.20	92
93	93.00	0.41	93.00	0.81	92.99	1.22	93
94	94.00	0.41	94.00	0.82	93.99	1.23	94
95	95.00	0.41	95.00	0.83	94.99	1.24	95
96	96.00	0.42	96.00	0.84	95.99	1.26	96
97	97.00	0.42	97.00	0.85	96.99	1.27	97
98	98.00	0.43	98.00	0.86	97.99	1.28	98
99	99.00	0.43	99.00	0.86	98.99	1.30	99
100	100.00	0.44	100.00	0.87	99.99	1.31	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	89¾ Deg.		89½ Deg.		89¼ Deg.		

Distance.	1 Deg.		1¼ Deg.		1½ Deg.		1¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.02	1.00	0.02	1.00	0.03	1.00	0.03	1
2	2.00	0.03	2.00	0.04	2.00	0.05	2.00	0.06	2
3	3.00	0.05	3.00	0.07	3.00	0.08	3.00	0.09	3
4	4.00	0.07	4.00	0.09	4.00	0.10	4.00	0.12	4
5	5.00	0.09	5.00	0.11	5.00	0.13	5.00	0.15	5
6	6.00	0.10	6.00	0.13	6.00	0.16	6.00	0.18	6
7	7.00	0.12	7.00	0.15	7.00	0.18	7.00	0.21	7
8	8.00	0.14	8.00	0.17	8.00	0.21	8.00	0.25	8
9	9.00	0.16	9.00	0.20	9.00	0.24	9.00	0.28	9
10	10.00	0.17	10.00	0.22	10.00	0.26	10.00	0.31	10
11	11.00	0.19	11.00	0.24	11.00	0.28	10.99	0.34	11
12	12.00	0.21	12.00	0.26	12.00	0.31	11.99	0.37	12
13	13.00	0.23	13.00	0.28	13.00	0.34	12.99	0.40	13
14	14.00	0.24	14.00	0.31	14.00	0.37	13.99	0.43	14
15	15.00	0.26	15.00	0.33	14.99	0.39	14.99	0.46	15
16	16.00	0.28	16.00	0.35	15.99	0.42	15.99	0.49	16
17	17.00	0.30	17.00	0.37	16.99	0.45	16.99	0.52	17
18	18.00	0.31	18.00	0.39	17.99	0.47	17.99	0.55	18
19	19.00	0.33	19.00	0.41	18.99	0.50	18.99	0.58	19
20	20.00	0.35	20.00	0.44	19.99	0.52	19.99	0.61	20
21	21.00	0.37	21.00	0.46	20.99	0.55	20.99	0.64	21
22	22.00	0.38	21.99	0.48	21.99	0.58	21.99	0.67	22
23	23.00	0.40	22.99	0.50	22.99	0.60	22.99	0.70	23
24	24.00	0.42	23.99	0.52	23.99	0.63	23.99	0.73	24
25	25.00	0.44	24.99	0.55	24.99	0.65	24.99	0.76	25
26	26.00	0.45	25.99	0.57	25.99	0.68	25.99	0.79	26
27	27.00	0.47	26.99	0.59	26.99	0.71	26.99	0.83	27
28	28.00	0.49	27.99	0.61	27.99	0.73	27.99	0.86	28
29	29.00	0.51	28.99	0.63	28.99	0.76	28.99	0.89	29
30	30.00	0.52	29.99	0.65	29.99	0.79	29.99	0.92	30
31	31.00	0.54	30.99	0.68	30.99	0.81	30.99	0.95	31
32	32.00	0.56	31.99	0.70	31.99	0.84	31.99	0.98	32
33	32.99	0.58	32.99	0.72	32.99	0.86	32.98	1.01	33
34	33.99	0.59	33.99	0.74	33.99	0.89	33.98	1.04	34
35	34.99	0.61	34.99	0.76	34.99	0.92	34.98	1.07	35
36	35.99	0.63	35.99	0.79	35.99	0.94	35.98	1.10	36
37	36.99	0.65	36.99	0.81	36.99	0.97	36.98	1.13	37
38	37.99	0.66	37.99	0.83	37.99	0.99	37.98	1.16	38
39	38.99	0.68	38.99	0.85	38.99	1.02	38.98	1.19	39
40	39.99	0.70	39.99	0.87	39.99	1.05	39.98	1.22	40
41	40.99	0.72	40.99	0.89	40.99	1.07	40.98	1.25	41
42	41.99	0.73	41.99	0.92	41.99	1.10	41.98	1.28	42
43	42.99	0.75	42.99	0.94	42.99	1.13	42.98	1.31	43
44	43.99	0.77	43.99	0.96	43.99	1.15	43.98	1.34	44
45	44.99	0.79	44.99	0.98	44.99	1.18	44.98	1.37	45
46	45.99	0.80	45.99	1.00	45.99	1.20	45.98	1.40	46
47	46.99	0.82	46.99	1.03	46.99	1.23	46.98	1.44	47
48	47.99	0.84	47.99	1.05	47.98	1.26	47.98	1.47	48
49	48.99	0.86	48.99	1.07	48.98	1.28	48.98	1.50	49
50	49.99	0.87	49.99	1.09	49.98	1.31	49.98	1.53	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	89 Deg.		88¾ Deg.		88½ Deg.		88¼ Deg.		

Distance.	1 Deg.		1¼ Deg.		1½ Deg.		1¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.99	0.89	50.99	1.11	50.98	1.34	50.98	1.56	51
52	51.99	0.91	51.99	1.13	51.98	1.36	51.98	1.59	52
53	52.99	0.92	52.99	1.16	52.98	1.39	52.98	1.62	53
54	53.99	0.94	53.99	1.18	53.98	1.41	53.97	1.65	54
55	54.99	0.96	54.99	1.20	54.98	1.44	54.97	1.68	55
56	55.99	0.98	55.99	1.22	55.98	1.47	55.97	1.71	56
57	56.99	0.99	56.99	1.24	56.98	1.49	56.97	1.74	57
58	57.99	1.01	57.99	1.27	57.98	1.52	57.97	1.77	58
59	58.99	1.03	58.99	1.29	58.98	1.54	58.97	1.80	59
60	59.99	1.05	59.99	1.31	59.98	1.57	59.97	1.83	60
61	60.99	1.06	60.99	1.33	60.98	1.60	60.97	1.86	61
62	61.99	1.08	61.99	1.35	61.98	1.62	61.97	1.89	62
63	62.99	1.10	62.99	1.37	62.98	1.65	62.97	1.92	63
64	63.99	1.12	63.98	1.40	63.98	1.68	63.97	1.95	64
65	64.99	1.13	64.98	1.42	64.98	1.70	64.97	1.99	65
66	65.99	1.15	65.98	1.44	65.98	1.73	65.97	2.02	66
67	66.99	1.17	66.98	1.46	66.98	1.75	66.97	2.05	67
68	67.99	1.19	67.98	1.48	67.98	1.78	67.97	2.08	68
69	68.99	1.20	68.98	1.51	68.98	1.81	68.97	2.11	69
70	69.99	1.22	69.98	1.53	69.98	1.83	69.97	2.14	70
71	70.99	1.24	70.98	1.55	70.98	1.86	70.97	2.17	71
72	71.99	1.26	71.98	1.57	71.98	1.88	71.97	2.20	72
73	72.99	1.27	72.98	1.59	72.97	1.91	72.97	2.23	73
74	73.99	1.29	73.98	1.61	73.97	1.94	73.97	2.26	74
75	74.99	1.31	74.98	1.64	74.97	1.96	74.97	2.29	75
76	75.99	1.33	75.98	1.66	75.97	1.99	75.96	2.32	76
77	76.99	1.34	76.98	1.68	76.97	2.02	76.96	2.35	77
78	77.99	1.36	77.98	1.70	77.97	2.04	77.96	2.38	78
79	78.99	1.38	78.98	1.72	78.97	2.07	78.96	2.41	79
80	79.99	1.40	79.98	1.75	79.97	2.09	79.96	2.44	80
81	80.99	1.41	80.98	1.77	80.97	2.12	80.96	2.47	81
82	81.99	1.43	81.98	1.79	81.97	2.15	81.96	2.50	82
83	82.99	1.45	82.98	1.81	82.97	2.17	82.96	2.53	83
84	83.99	1.47	83.98	1.83	83.97	2.20	83.96	2.57	84
85	84.99	1.48	84.98	1.85	84.97	2.23	84.96	2.60	85
86	85.99	1.50	85.98	1.88	85.97	2.25	85.96	2.63	86
87	86.99	1.52	86.98	1.90	86.97	2.28	86.96	2.66	87
88	87.99	1.54	87.98	1.92	87.97	2.30	87.96	2.69	88
89	88.99	1.55	88.98	1.94	88.97	2.33	88.96	2.72	89
90	89.99	1.57	89.98	1.96	89.97	2.36	89.96	2.75	90
91	90.99	1.59	90.98	1.99	90.97	2.38	90.96	2.78	91
92	91.99	1.61	91.98	2.01	91.97	2.41	91.96	2.81	92
93	92.99	1.62	92.98	2.03	92.97	2.43	92.96	2.84	93
94	93.99	1.64	93.98	2.05	93.97	2.46	93.96	2.87	94
95	94.99	1.66	94.98	2.07	94.97	2.49	94.96	2.90	95
96	95.99	1.68	95.98	2.09	95.97	2.51	95.96	2.94	96
97	96.99	1.69	96.98	2.12	96.97	2.54	96.95	2.96	97
98	97.99	1.71	97.98	2.14	97.97	2.57	97.95	2.99	98
99	98.98	1.73	98.98	2.16	98.97	2.59	98.95	3.02	99
100	99.98	1.75	99.98	2.18	99.97	2.62	99.95	3.05	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	89 Deg.		88¾ Deg.		88½ Deg.		88¼ Deg.		

Distance.	2 Deg.		2¼ Deg.		2½ Deg.		2¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.03	1.00	0.04	1.00	0.04	1.00	0.05	1
2	2.00	0.07	2.00	0.08	2.00	0.09	2.00	0.10	2
3	3.00	0.10	3.00	0.12	3.00	0.13	3.00	0.14	3
4	4.00	0.14	4.00	0.16	4.00	0.17	4.00	0.19	4
5	5.00	0.17	5.00	0.20	5.00	0.22	4.99	0.24	5
6	6.00	0.21	6.00	0.24	5.99	0.26	5.99	0.29	6
7	7.00	0.24	6.99	0.27	6.99	0.31	6.99	0.34	7
8	7.99	0.28	7.99	0.31	7.99	0.35	7.99	0.38	8
9	8.99	0.31	8.99	0.35	8.99	0.39	8.99	0.43	9
10	9.99	0.35	9.99	0.39	9.99	0.44	9.99	0.48	10
11	10.99	0.38	10.99	0.43	10.99	0.48	10.99	0.53	11
12	11.99	0.42	11.99	0.47	11.99	0.52	11.99	0.58	12
13	12.99	0.45	12.99	0.51	12.99	0.57	12.99	0.62	13
14	13.99	0.49	13.99	0.55	13.99	0.61	13.98	0.67	14
15	14.99	0.52	14.99	0.59	14.99	0.65	14.98	0.72	15
16	15.99	0.56	15.99	0.63	15.99	0.70	15.98	0.77	16
17	16.99	0.59	16.99	0.67	16.98	0.74	16.98	0.82	17
18	17.99	0.63	17.99	0.71	17.98	0.79	17.98	0.86	18
19	18.99	0.66	18.99	0.75	18.98	0.83	18.98	0.91	19
20	19.99	0.70	19.98	0.79	19.98	0.87	19.98	0.96	20
21	20.99	0.73	20.98	0.82	20.98	0.92	20.98	1.01	21
22	21.99	0.77	21.98	0.86	21.98	0.96	21.97	1.06	22
23	22.99	0.80	22.98	0.90	22.98	1.00	22.97	1.10	23
24	23.99	0.84	23.98	0.94	23.98	1.05	23.97	1.15	24
25	24.98	0.87	24.98	0.98	24.98	1.09	24.97	1.20	25
26	25.98	0.91	25.98	1.02	25.98	1.13	25.97	1.25	26
27	26.98	0.94	26.98	1.06	26.97	1.18	26.97	1.30	27
28	27.98	0.98	27.98	1.10	27.97	1.22	27.97	1.34	28
29	28.98	1.01	28.98	1.14	28.97	1.26	28.97	1.39	29
30	29.98	1.05	29.98	1.18	29.97	1.31	29.97	1.44	30
31	30.98	1.08	30.98	1.22	30.97	1.35	30.96	1.49	31
32	31.98	1.12	31.98	1.26	31.97	1.40	31.96	1.54	32
33	32.98	1.15	32.97	1.30	32.97	1.44	32.96	1.58	33
34	33.98	1.19	33.97	1.33	33.97	1.48	33.96	1.63	34
35	34.98	1.22	34.97	1.37	34.97	1.53	34.96	1.68	35
36	35.98	1.26	35.97	1.41	35.97	1.57	35.96	1.73	36
37	36.98	1.29	36.97	1.45	36.96	1.61	36.96	1.78	37
38	37.98	1.33	37.97	1.49	37.96	1.66	37.96	1.82	38
39	38.98	1.36	38.97	1.53	38.96	1.70	38.96	1.87	39
40	39.98	1.40	39.97	1.57	39.96	1.75	39.95	1.92	40
41	40.98	1.43	40.97	1.61	40.96	1.77	40.95	1.97	41
42	41.97	1.47	41.97	1.65	41.96	1.83	41.95	2.02	42
43	42.97	1.50	42.97	1.69	42.96	1.88	42.95	2.06	43
44	43.97	1.54	43.97	1.73	43.96	1.92	43.95	2.11	44
45	44.97	1.57	44.97	1.77	44.96	1.96	44.95	2.16	45
46	45.97	1.61	45.96	1.81	45.96	2.01	45.95	2.21	46
47	46.97	1.64	46.96	1.85	46.96	2.05	46.95	2.25	47
48	47.97	1.68	47.96	1.88	47.95	2.09	47.95	2.30	48
49	48.97	1.71	48.96	1.92	48.95	2.14	48.94	2.35	49
50	49.97	1.74	49.96	1.96	49.95	2.18	49.94	2.40	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	88 Deg.		87¾ Deg.		87½ Deg.		87¼ Deg.		

Distance.	2 Deg.		2¼ Deg.		2½ Deg.		2¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.97	1.78	50.96	2.00	50.95	2.22	50.94	2.45	51
52	51.97	1.81	51.96	2.04	51.95	2.27	51.94	2.50	52
53	52.97	1.85	52.96	2.08	52.95	2.31	52.94	2.54	53
54	53.97	1.88	53.96	2.12	53.95	2.36	53.94	2.59	54
55	54.97	1.92	54.96	2.16	54.95	2.40	54.94	2.64	55
56	55.97	1.95	55.96	2.20	55.95	2.44	55.94	2.69	56
57	56.97	1.99	56.96	2.24	56.95	2.49	56.93	2.73	57
58	57.96	2.02	57.96	2.28	57.94	2.53	57.93	2.78	58
59	58.96	2.06	58.95	2.32	58.94	2.57	58.93	2.83	59
60	59.96	2.09	59.95	2.36	59.94	2.62	59.93	2.88	60
61	60.96	2.13	60.95	2.39	60.94	2.66	60.93	2.93	61
62	61.96	2.16	61.95	2.43	61.94	2.70	61.93	2.97	62
63	62.96	2.20	62.95	2.47	62.94	2.75	62.93	3.02	63
64	63.96	2.23	63.95	2.51	63.94	2.79	63.93	3.07	64
65	64.96	2.27	64.95	2.55	64.94	2.84	64.93	3.12	65
66	65.96	2.30	65.95	2.59	65.94	2.88	65.92	3.17	66
67	66.96	2.34	66.95	2.63	66.94	2.92	66.92	3.21	67
68	67.96	2.37	67.95	2.67	67.94	2.97	67.92	3.26	68
69	68.96	2.41	68.95	2.71	68.93	3.01	68.92	3.31	69
70	69.96	2.44	69.95	2.75	69.93	3.05	69.92	3.36	70
71	70.96	2.48	70.95	2.79	70.93	3.10	70.92	3.41	71
72	71.96	2.51	71.94	2.83	71.93	3.14	71.92	3.45	72
73	72.96	2.55	72.94	2.87	72.93	3.18	72.92	3.50	73
74	73.95	2.58	73.94	2.91	73.93	3.23	73.91	3.55	74
75	74.95	2.62	74.94	2.94	74.93	3.27	74.91	3.60	75
76	75.95	2.65	75.94	2.98	75.93	3.31	75.91	3.65	76
77	76.95	2.69	76.94	3.02	76.93	3.36	76.91	3.70	77
78	77.95	2.72	77.94	3.06	77.93	3.40	77.91	3.74	78
79	78.95	2.76	78.94	3.10	78.92	3.45	78.91	3.79	79
80	79.95	2.79	79.94	3.14	79.92	3.49	79.91	3.84	80
81	80.95	2.83	80.94	3.18	80.92	3.53	80.91	3.89	81
82	81.95	2.86	81.94	3.22	81.92	3.58	81.91	3.93	82
83	82.95	2.90	82.94	3.26	82.92	3.62	82.90	3.98	83
84	83.95	2.93	83.94	3.30	83.92	3.66	83.90	4.03	84
85	84.95	2.97	84.93	3.34	84.92	3.71	84.90	4.08	85
86	85.95	3.00	85.93	3.38	85.92	3.75	85.90	4.13	86
87	86.95	3.04	86.93	3.42	86.92	3.79	86.90	4.17	87
88	87.95	3.07	87.93	3.45	87.92	3.84	87.90	4.22	88
89	88.95	3.11	88.93	3.49	88.92	3.88	88.90	4.27	89
90	89.95	3.14	89.93	3.53	89.91	3.93	89.90	4.32	90
91	90.95	3.18	90.93	3.57	90.91	3.97	90.90	4.37	91
92	91.94	3.21	91.93	3.61	91.91	4.01	91.89	4.41	92
93	92.94	3.25	92.93	3.65	92.91	4.06	92.89	4.46	93
94	93.94	3.28	93.93	3.69	93.91	4.10	93.89	4.51	94
95	94.94	3.32	94.93	3.73	94.91	4.14	94.89	4.56	95
96	95.94	3.35	95.93	3.77	95.91	4.19	95.89	4.61	96
97	96.94	3.39	96.93	3.81	96.91	4.23	96.89	4.65	97
98	97.94	3.42	97.92	3.85	97.91	4.27	97.89	4.70	98
99	98.94	3.46	98.92	3.89	98.91	4.32	98.89	4.75	99
100	99.94	3.49	99.92	3.93	99.91	4.36	99.88	4.80	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	88 Deg.		87¾ Deg.		87½ Deg.		87¼ Deg.		

Distance.	3 Deg.		3¼ Deg.		3½ Deg.		3¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.05	1.00	0.06	1.00	0.06	1.00	0.06	1
2	2.00	0.10	2.00	0.11	2.00	0.12	2.00	0.13	2
3	3.00	0.16	3.00	0.17	2:99	0.18	2.99	0.20	3
4	3.99	0.21	3.99	0.23	3.99	0.24	3.99	0.26	4
5	4.99	0.26	4.99	0.28	4.99	0.31	4.99	0.33	5
6	5.99	0.31	5.99	0.34	5.99	0.37	5.99	0.39	6
7	6.99	0.37	6.99	0.40	6.99	0.43	6.99	0.46	7
8	7.99	0.42	7.99	0.45	7.99	0.49	7.98	0.52	8
9	8.99	0.47	8.99	0.51	8.98	0.55	8.98	0.59	9
10	9.99	0.52	9.98	0.57	9.98	0.61	9.98	0.65	10
11	10.98	0.58	10.98	0.62	10.98	0.67	10.98	0.72	11
12	11.98	0.63	11.98	0.68	11.98	0.73	11.97	0.78	12
13	12.98	0.68	12.98	0.73	12.98	0.79	12.97	0.85	13
14	13.98	0.73	13.98	0.79	13.97	0.85	13.97	0.92	14
15	14.98	0.79	14.98	0.85	14.97	0.92	14.97	0.98	15
16	15.98	0.84	15.97	0.91	15.97	0.98	15.97	1.05	16
17	16.98	0.89	16.97	0.96	16.97	1.04	16.96	1.11	17
18	17.98	0.94	17.97	1.02	17.97	1.10	17.96	1.18	18
19	18.98	0.99	18.97	1.08	18.96	1.16	18.96	1.24	19
20	19.97	1.05	19.97	1.13	19.96	1.22	19.96	1.31	20
21	20.97	1.10	20.97	1.19	20.96	1.28	20.96	1.37	21
22	21.97	1.15	21.96	1.25	21.96	1.34	21.95	1.44	22
23	22.97	1.20	22.96	1.30	22.96	1.40	22.95	1.50	23
24	23.97	1.26	23.96	1.36	23.96	1.47	23.95	1.57	24
25	24.97	1.31	24.96	1.42	24.95	1.53	24.95	1.64	25
26	25.96	1.36	25.96	1.47	25.95	1.59	25.94	1.70	26
27	26.96	1.41	26.96	1.53	26.95	1.65	26.94	1.77	27
28	27.96	1.47	27.95	1.59	27.95	1.71	27.94	1.83	28
29	28.96	1.52	28.95	1.64	28.95	1.77	28.94	1.90	29
30	29.96	1.57	29.95	1.70	29.94	1.83	29.94	1.96	30
31	30.96	1.62	30.95	1.76	30.94	1.89	30.93	2.03	31
32	31.96	1.67	31.95	1.81	31.94	1.95	31.93	2.09	32
33	32.95	1.73	32.95	1.87	32.94	2.01	32.93	2.16	33
34	33.95	1.78	33.95	1.93	33.94	2.08	33.93	2.22	34
35	34.95	1.83	34.94	1.98	34.93	2.14	34.92	2.29	35
36	35.95	1.88	35.94	2.04	35.93	2.20	35.92	2.35	36
37	36.95	1.94	36.94	2.10	36.93	2.26	36.92	2.42	37
38	37.95	1.99	37.94	2.15	37.93	2.32	37.92	2.49	38
39	38.95	2.04	38.94	2.21	38.93	2.38	38.92	2.55	39
40	39.95	2.09	39.94	2.27	39.93	2.44	39.91	2.62	40
41	40.94	2.15	40.93	2.32	40.92	2.50	40.91	2.68	41
42	41.94	2.20	41.93	2.38	41.92	2.56	41.91	2.75	42
43	42.94	2.25	42.93	2.44	42.92	2.63	42.91	2.81	43
44	43.94	2.30	43.93	2.49	43.92	2.69	43.91	2.88	44
45	44.94	2.36	44.93	2.55	44.92	2.75	44.90	2.94	45
46	45.94	2.41	45.93	2.61	45.91	2.81	45.90	3.01	46
47	46.94	2.46	46.92	2.66	46.91	2.87	46.90	3.07	47
48	47.93	2.51	47.92	2.72	47.91	2.93	47.90	3.14	48
49	48.93	2.56	48.92	2.78	48.91	2.99	48.90	3.20	49
50	49.93	2.62	49.92	2.83	49.91	3.05	49.89	3.27	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	87 Deg.		86¾ Deg.		86½ Deg.		86¼ Deg.		

Distance.	3 Deg.		3¼ Deg.		3½ Deg.		3¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.93	2.67	50.92	2.89	50.90	3.11	50.89	3.34	51
52	51.93	2.72	51.92	2.95	51.90	3.17	51.89	3.40	52
53	52.93	2.77	52.91	3.00	52.90	3.24	52.89	3.47	53
54	53.93	2.83	53.91	3.06	53.90	3.30	53.88	3.53	54
55	54.92	2.88	54.91	3.12	54.90	3.36	54.88	3.60	55
56	55.92	2.93	55.91	3.17	55.90	3.42	55.88	3.66	56
57	56.92	2.98	56.91	3.23	56.89	3.48	56.88	3.73	57
58	57.92	3.04	57.91	3.29	57.89	3.54	57.88	3.79	58
59	58.92	3.09	58.91	3.34	58.89	3.60	58.87	3.86	59
60	59.92	3.14	59.90	3.40	59.89	3.66	59.87	3.92	60
61	60.92	3.19	60.90	3.46	60.89	3.72	60.87	3.99	61
62	61.92	3.24	61.90	3.51	61.88	3.79	61.87	4.05	62
63	62.91	3.30	62.90	3.57	62.88	3.85	62.87	4.12	63
64	63.91	3.35	63.90	3.63	63.88	3.91	63.86	4.19	64
65	64.91	3.40	64.90	3.69	64.88	3.97	64.86	4.25	65
66	65.91	3.45	65.89	3.74	65.88	4.03	65.86	4.32	66
67	66.91	3.51	66.89	3.80	66.88	4.09	66.86	4.38	67
68	67.91	3.56	67.89	3.86	67.87	4.15	67.85	4.45	68
69	68.91	3.61	68.89	3.91	68.87	4.21	68.85	4.51	69
70	69.90	3.66	69.89	3.97	69.87	4.27	69.85	4.58	70
71	70.90	3.72	70.89	4.03	70.87	4.33	70.85	4.64	71
72	71.90	3.77	71.88	4.08	71.87	4.40	71.85	4.71	72
73	72.90	3.82	72.88	4.14	72.86	4.46	72.84	4.77	73
74	73.90	3.87	73.88	4.20	73.86	4.52	73.84	4.84	74
75	74.90	3.93	74.88	4.25	74.86	4.58	74.84	4.91	75
76	75.90	3.98	75.88	4.31	75.86	4.64	75.84	4.97	76
77	76.89	4.03	76.88	4.37	76.86	4.70	76.84	5.04	77
78	77.89	4.08	77.87	4.42	77.85	4.76	77.83	5.10	78
79	78.89	4.13	78.87	4.48	78.85	4.82	78.83	5.17	79
80	79.89	4.19	79.87	4.54	79.85	4.88	79.83	5.23	80
81	80.89	4.24	80.87	4.59	80.85	4.94	80.83	5.30	81
82	81.89	4.29	81.87	4.65	81.85	5.01	81.82	5.36	82
83	82.89	4.34	82.87	4.71	82.85	5.07	82.82	5.43	83
84	83.88	4.40	83.86	4.76	83.84	5.13	83.82	5.49	84
85	84.88	4.45	84.86	4.82	84.84	5.19	84.82	5.56	85
86	85.88	4.50	85.86	4.88	85.84	5.25	85.82	5.62	86
87	86.88	4.55	86.86	4.93	86.84	5.31	86.81	5.69	87
88	87.88	4.61	87.86	4.99	87.84	5.37	87.81	5.76	88
89	88.88	4.66	88.86	5.05	88.83	5.43	88.81	5.82	89
90	89.88	4.71	89.86	5.10	89.83	5.49	89.81	5.89	90
91	90.88	4.76	90.85	5.16	90.83	5.56	90.81	5.95	91
92	91.87	4.81	91.85	5.22	91.83	5.62	91.80	6.02	92
93	92.87	4.87	92.85	5.27	92.83	5.68	92.80	6.08	93
94	93.87	4.92	93.85	5.33	93.82	5.74	93.80	6.15	94
95	94.87	4.97	94.85	5.39	94.82	5.80	94.80	6.21	95
96	95.87	5.02	95.85	5.44	95.82	5.86	95.79	6.28	96
97	96.87	5.08	96.84	5.50	96.82	5.92	96.79	6.34	97
98	97.87	5.13	97.84	5.56	97.82	5.98	97.79	6.41	98
99	98.86	5.18	98.84	5.61	98.82	6.04	98.79	6.47	99
100	99.86	5.23	99.84	5.67	99.81	6.10	99.79	6.54	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	87 Deg.		86¾ Deg.		86½ Deg.		86¼ Deg.		

Distance.	4 Deg.		4¼ Deg.		4½ Deg.		4¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.07	1.00	0.07	1.00	0.08	1.00	0.08	1
2	2.00	0.14	1.99	0.15	1.99	0.16	1.99	0.17	2
3	2.99	0.21	2.99	0.22	2.99	0.24	2.99	0.25	3
4	3.99	0.28	3.99	0.30	3.99	0.31	3.98	0.33	4
5	4.99	0.35	4.99	0.37	4.98	0.39	4.98	0.41	5
6	5.99	0.42	5.98	0.44	5.98	0.47	5.98	0.50	6
7	6.98	0.49	6.98	0.52	6.98	0.55	6.97	0.58	7
8	7.98	0.56	7.98	0.59	7.98	0.63	7.97	0.66	8
9	8.98	0.63	8.98	0.67	8.97	0.71	8.97	0.75	9
10	9.98	0.70	9.97	0.74	9.97	0.78	9.97	0.83	10
11	10.97	0.77	10.97	0.82	10.97	0.86	10.96	0.91	11
12	11.97	0.84	11.97	0.89	11.96	0.94	11.96	0.99	12
13	12.97	0.91	12.96	0.96	12.96	1.02	12.96	1.08	13
14	13.97	0.98	13.96	1.04	13.96	1.10	13.95	1.16	14
15	14.96	1.05	14.96	1.11	14.95	1.18	14.95	1.24	15
16	15.96	1.12	15.96	1.19	15.95	1.26	15.95	1.32	16
17	16.96	1.19	16.95	1.26	16.95	1.33	16.94	1.41	17
18	17.96	1.26	17.95	1.33	17.94	1.41	17.94	1.49	18
19	18.95	1.33	18.95	1.40	18.94	1.49	18.93	1.57	19
20	19.95	1.40	19.95	1.48	19.94	1.57	19.93	1.66	20
21	20.95	1.46	20.94	1.56	20.94	1.65	20.93	1.74	21
22	21.95	1.53	21.94	1.63	21.93	1.73	21.92	1.82	22
23	22.94	1.60	22.94	1.70	22.93	1.80	22.92	1.90	23
24	23.94	1.67	23.93	1.78	23.93	1.88	23.92	1.99	24
25	24.94	1.74	24.93	1.85	24.92	1.96	24.91	2.07	25
26	25.94	1.81	25.93	1.93	25.92	2.04	25.91	2.15	26
27	26.93	1.88	26.93	2.00	26.92	2.12	26.91	2.24	27
28	27.93	1.95	27.92	2.08	27.91	2.20	27.90	2.32	28
29	28.93	2.02	28.92	2.15	28.91	2.28	28.90	2.40	29
30	29.93	2.09	29.92	2.22	29.91	2.35	29.90	2.48	30
31	30.92	2.16	30.91	2.30	30.90	2.43	30.89	2.57	31
32	31.92	2.23	31.91	2.37	31.90	2.51	31.89	2.65	32
33	32.92	2.30	32.91	2.45	32.90	2.59	32.89	2.73	33
34	33.92	2.37	33.91	2.52	33.90	2.67	33.88	2.82	34
35	34.91	2.44	34.90	2.59	34.89	2.75	34.88	2.90	35
36	35.91	2.51	35.90	2.67	35.89	2.82	35.88	2.98	36
37	36.91	2.58	36.90	2.74	36.89	2.90	36.87	3.06	37
38	37.91	2.65	37.90	2.82	37.88	2.98	37.87	3.15	38
39	38.90	2.72	38.89	2.89	38.88	3.06	38.87	3.23	39
40	39.90	2.79	39.89	2.96	39.88	3.14	39.86	3.31	40
41	40.90	2.86	40.89	3.04	40.87	3.22	40.86	3.40	41
42	41.90	2.93	41.88	3.11	41.87	3.30	41.86	3.48	42
43	42.90	3.00	42.88	3.19	42.87	3.37	42.85	3.56	43
44	43.89	3.07	43.88	3.26	43.86	3.45	43.85	3.64	44
45	44.89	3.14	44.88	3.33	44.86	3.53	44.85	3.73	45
46	45.89	3.21	45.87	3.41	45.86	3.61	45.84	3.81	46
47	46.89	3.28	46.87	3.48	46.86	3.69	46.84	3.89	47
48	47.88	3.35	47.87	3.56	47.85	3.77	47.84	3.97	48
49	48.88	3.42	48.87	3.63	48.85	3.84	48.83	4.06	49
50	49.88	3.49	49.86	3.71	49.85	3.92	49.83	4.14	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	86 Deg.		85¾ Deg.		85½ Deg.		85¼ Deg.		

Distance.	4 Deg.		4¼ Deg.		4½ Deg.		4¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.88	3.56	50.86	3.78	50.84	4.00	50.82	4.22	51
52	51.87	3.63	51.86	3.85	51.84	4.08	51.82	4.31	52
53	52.87	3.70	52.85	3.93	52.84	4.16	52.82	4.39	53
54	53.87	3.77	53.85	4.00	53.83	4.24	53.81	4.47	54
55	54.87	3.84	54.85	4.08	54.83	4.32	54.81	4.55	55
56	55.86	3.91	55.85	4.15	55.83	4.39	55.81	4.64	56
57	56.86	3.98	56.84	4.22	56.82	4.47	56.80	4.72	57
58	57.86	4.05	57.84	4.30	57.82	4.55	57.80	4.80	58
59	58.86	4.12	58.84	4.37	58.82	4.63	58.80	4.89	59
60	59.85	4.19	59.84	4.45	59.82	4.71	59.79	4.97	60
61	60.85	4.26	60.83	4.52	60.81	4.79	60.79	5.05	61
62	61.85	4.32	61.83	4.59	61.81	4.86	61.79	5.13	62
63	62.85	4.39	62.83	4.67	62.81	4.94	62.78	5.22	63
64	63.84	4.46	63.82	4.74	63.80	5.02	63.78	5.30	64
65	64.84	4.53	64.82	4.82	64.80	5.10	64.78	5.38	65
66	65.84	4.60	65.82	4.89	65.80	5.18	65.77	5.47	66
67	66.84	4.67	66.82	4.97	66.79	5.26	66.77	5.55	67
68	67.83	4.74	67.81	5.04	67.79	5.34	67.77	5.63	68
69	68.83	4.81	68.81	5.11	68.79	5.41	68.76	5.71	69
70	69.83	4.88	69.81	5.19	69.78	5.49	69.76	5.80	70
71	70.83	4.95	70.80	5.26	70.78	5.57	70.76	5.88	71
72	71.82	5.02	71.80	5.34	71.78	5.65	71.75	5.96	72
73	72.82	5.09	72.80	5.41	72.77	5.73	72.75	6.04	73
74	73.82	5.16	73.80	5.48	73.77	5.81	73.75	6.13	74
75	74.82	5.23	74.79	5.56	74.77	5.88	74.74	6.21	75
76	75.81	5.30	75.79	5.63	75.77	5.96	75.74	6.29	76
77	76.81	5.37	76.79	5.71	76.76	6.04	76.74	6.38	77
78	77.81	5.44	77.79	5.78	77.76	6.12	77.73	6.46	78
79	78.81	5.51	78.78	5.85	78.76	6.20	78.73	6.54	79
80	79.81	5.58	79.78	5.93	79.75	6.28	79.73	6.62	80
81	80.80	5.65	80.78	6.00	80.75	6.36	80.72	6.71	81
82	81.80	5.72	81.78	6.08	81.75	6.43	81.72	6.79	82
83	82.80	5.79	82.77	6.15	82.74	6.51	82.71	6.87	83
84	83.80	5.86	83.77	6.23	83.74	6.59	83.71	6.96	84
85	84.79	5.93	84.77	6.30	84.74	6.67	84.71	7.04	85
86	85.79	6.00	85.76	6.37	85.73	6.75	85.70	7.12	86
87	86.79	6.07	86.76	6.45	86.73	6.83	86.70	7.20	87
88	87.79	6.14	87.76	6.52	87.73	6.90	87.70	7.29	88
89	88.78	6.21	88.76	6.60	88.73	6.98	88.70	7.37	89
90	89.78	6.28	89.75	6.67	89.72	7.06	89.69	7.45	90
91	90.78	6.35	90.75	6.74	90.72	7.14	90.69	7.54	91
92	91.78	6.42	91.75	6.82	91.72	7.22	91.68	7.62	92
93	92.77	6.49	92.74	6.89	92.71	7.30	92.68	7.70	93
94	93.77	6.56	93.74	6.97	93.71	7.38	93.68	7.78	94
95	94.77	6.63	94.74	7.04	94.71	7.45	94.67	7.87	95
96	95.77	6.70	95.74	7.11	95.70	7.53	95.67	7.95	96
97	96.76	6.77	96.73	7.19	96.70	7.61	96.67	8.03	97
98	97.76	6.84	97.73	7.26	97.70	7.69	97.66	8.12	98
99	98.76	6.91	98.73	7.34	98.69	7.77	98.66	8.20	99
100	99.76	6.98	99.73	7.41	99.69	7.85	99.66	8.28	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	86 Deg.		85¾ Deg.		85½ Deg.		85¼ Deg.		

Distance.	5 Deg.		5¼ Deg.		5½ Deg.		5¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1.00	0.09	1.00	0.09	1.00	0.10	0.99	0.10	1
2	1.99	0.17	1.99	0.18	1.99	0.19	1.99	0.20	2
3	2.99	0.26	2.99	0.27	2.99	0.29	2.98	0.30	3
4	3.98	0.35	3.98	0.37	3.98	0.38	3.98	0.40	4
5	4.98	0.44	4.98	0.46	4.98	0.48	4.97	0.50	5
6	5.98	0.52	5.97	0.55	5.97	0.58	5.97	0.60	6
7	6.97	0.61	6.97	0.64	6.97	0.67	6.96	0.70	7
8	7.97	0.70	7.97	0.73	7.96	0.76	7.96	0.80	8
9	8.97	0.78	8.96	0.82	8.96	0.86	8.95	0.90	9
10	9.96	0.87	9.96	0.92	9.95	0.96	9.95	1.00	10
11	10.96	0.96	10.95	1.01	10.95	1.05	10.94	1.10	11
12	11.95	1.05	11.95	1.10	11.94	1.15	11.94	1.20	12
13	12.95	1.13	12.95	1.19	12.94	1.25	12.93	1.30	13
14	13.95	1.22	13.94	1.28	13.94	1.34	13.93	1.40	14
15	14.94	1.31	14.94	1.37	14.93	1.44	14.92	1.50	15
16	15.94	1.39	15.93	1.46	15.93	1.53	15.92	1.60	16
17	16.94	1.48	16.93	1.56	16.92	1.63	16.91	1.70	17
18	17.93	1.57	17.92	1.65	17.92	1.73	17.91	1.80	18
19	18.93	1.66	18.92	1.74	18.91	1.82	18.90	1.90	19
20	19.92	1.74	19.92	1.83	19.91	1.92	19.90	2.00	20
21	20.92	1.83	20.91	1.92	20.90	2.01	20.89	2.10	21
22	21.92	1.92	21.91	2.01	21.90	2.11	21.89	2.20	22
23	22.91	2.00	22.90	2.10	22.89	2.20	22.88	2.30	23
24	23.91	2.09	23.90	2.20	23.89	2.30	23.88	2.40	24
25	24.90	2.18	24.90	2.29	24.88	2.40	24.87	2.50	25
26	25.90	2.27	25.89	2.38	25.88	2.49	25.87	2.60	26
27	26.90	2.35	26.89	2.47	26.88	2.59	26.86	2.71	27
28	27.89	2.44	27.88	2.56	27.87	2.68	27.86	2.81	28
29	28.89	2.53	28.88	2.65	28.87	2.78	28.85	2.91	29
30	29.89	2.61	29.87	2.75	29.86	2.88	29.85	3.01	30
31	30.88	2.70	30.87	2.84	30.86	2.97	30.84	3.11	31
32	31.88	2.79	31.87	2.93	31.85	3.07	31.84	3.21	32
33	32.87	2.88	32.86	3.02	32.85	3.16	32.83	3.31	33
34	33.87	2.96	33.86	3.11	33.84	3.26	33.83	3.41	34
35	34.87	3.05	34.85	3.20	34.84	3.35	34.82	3.51	35
36	35.86	3.14	35.85	3.29	35.83	3.45	35.82	3.61	36
37	36.86	3.22	36.84	3.39	36.83	3.55	36.81	3.71	37
38	37.86	3.31	37.84	3.48	37.83	3.64	37.81	3.81	38
39	38.85	3.40	38.64	3.57	38.82	3.74	38.80	3.91	39
40	39.85	3.49	39.83	3.66	39.82	3.83	39.80	4.01	40
41	40.84	3.57	40.83	3.75	40.81	3.93	40.79	4.11	41
42	41.84	3.66	41.82	3.84	41.81	4.03	41.79	4.21	42
43	42.84	3.75	42.82	3.93	42.80	4.12	42.78	4.31	43
44	43.83	3.83	43.82	4.03	43.80	4.22	43.78	4.41	44
45	44.83	3.92	44.81	4.12	44.79	4.31	44.77	4.51	45
46	45.82	4.01	45.81	4.21	45.79	4.41	45.77	4.61	46
47	46.82	4.10	46.80	4.30	46.78	4.50	46.76	4.71	47
48	47.82	4.18	47.80	4.39	47.78	4.60	47.76	4.81	48
49	48.81	4.27	48.79	4.48	48.77	4.70	48.75	4.91	49
50	49.81	4.36	49.79	4.58	49.77	4.79	49.75	5.01	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	85 Deg.		84¾ Deg.		84½ Deg.		84¼ Deg.		

Distance.	5 Deg.		5¼ Deg.		5½ Deg.		5¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.81	4.44	50.79	4.67	50.77	4.89	50.74	5.11	51
52	51.80	4.53	51.78	4.76	51.76	4.98	51.74	5.21	52
53	52.80	4.62	52.78	4.85	52.76	5.08	52.73	5.31	53
54	53.79	4.71	53.77	4.94	53.75	5.18	53.73	5.41	54
55	54.79	4.79	54.77	5.03	54.75	5.27	54.72	5.51	55
56	55.79	4.88	55.77	5.12	55.74	5.37	55.72	5.61	56
57	56.78	4.97	56.76	5.22	56.74	5.46	56.71	5.71	57
58	57.78	5.06	57.76	5.31	57.73	5.56	57.71	5.81	58
59	58.78	5.14	58.75	5.40	58.73	5.65	58.70	5.91	59
60	59.77	5.23	59.75	5.49	59.72	5.75	59.70	6.01	60
61	60.77	5.32	60.74	5.58	60.72	5.85	60.69	6.11	61
62	61.76	5.40	61.74	5.67	61.71	5.94	61.69	6.21	62
63	62.76	5.49	62.74	5.76	62.71	6.04	62.68	6.31	63
64	63.76	5.58	63.73	5.86	63.71	6.13	63.68	6.41	64
65	64.75	5.67	64.73	5.95	64.70	6.23	64.67	6.51	65
66	65.75	5.75	65.72	6.04	65.70	6.33	65.67	6.61	66
67	66.75	5.84	66.72	6.13	66.69	6.42	66.66	6.71	67
68	67.74	5.93	67.71	6.22	67.69	6.52	67.66	6.81	68
69	68.74	6.01	68.71	6.31	68.68	6.61	68.65	6.91	69
70	69.73	6.10	69.71	6.41	69.68	6.71	69.65	7.01	70
71	70.73	6.19	70.70	6.50	70.67	6.81	70.64	7.11	71
72	71.73	6.28	71.70	6.59	71.67	6.90	71.64	7.21	72
73	72.72	6.36	72.69	6.68	72.66	7.00	72.63	7.31	73
74	73.72	6.45	73.69	6.77	73.66	7.09	73.63	7.41	74
75	74.71	6.54	74.69	6.86	74.65	7.19	74.62	7.51	75
76	75.71	6.62	75.68	6.95	75.65	7.28	75.62	7.61	76
77	76.71	6.71	76.68	7.05	76.65	7.38	76.61	7.71	77
78	77.70	6.80	77.67	7.14	77.64	7.48	77.61	7.81	78
79	78.70	6.89	78.67	7.23	78.64	7.57	78.60	7.91	79
80	79.70	6.97	79.66	7.32	79.63	7.67	79.60	8.02	80
81	80.69	7.06	80.66	7.41	80.63	7.76	80.59	8.12	81
82	81.69	7.15	81.66	7.50	81.62	7.86	81.59	8.22	82
83	82.68	7.23	82.65	7.59	82.62	7.96	82.58	8.32	83
84	83.68	7.32	83.65	7.69	83.61	8.05	83.58	8.42	84
85	84.68	7.41	84.64	7.78	84.61	8.15	84.57	8.52	85
86	85.67	7.50	85.64	7.87	85.60	8.24	85.57	8.62	86
87	86.67	7.58	86.64	7.96	86.60	8.34	86.56	8.72	87
88	87.67	7.67	87.63	8.05	87.59	8.43	87.56	8.82	88
89	88.66	7.76	88.63	8.14	88.59	8.53	88.55	8.92	89
90	89.66	7.84	89.62	8.24	89.59	8.63	89.55	9.02	90
91	90.65	7.93	90.62	8.33	90.58	8.72	90.54	9.12	91
92	91.65	8.02	91.61	8.42	91.58	8.82	91.54	9.22	92
93	92.65	8.11	92.61	8.51	92.57	8.91	92.53	9.32	93
94	93.64	8.19	93.61	8.60	93.57	9.01	93.53	9.42	94
95	94.64	8.28	94.60	8.69	94.56	9.11	94.52	9.52	95
96	95.63	8.37	95.60	8.78	95.56	9.20	95.52	9.62	96
97	96.63	8.45	96.59	8.88	96.55	9.30	96.51	9.72	97
98	97.63	8.54	97.59	8.97	97.55	9.39	97.51	9.82	98
99	98.62	8.63	98.59	9.06	98.54	9.49	98.50	9.92	99
100	99.62	8.72	99.58	9.15	99.54	9.58	99.50	10.02	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	85 Deg.		84¾ Deg.		84½ Deg.		84¼ Deg.		

Distance.	6 Deg.		6¼ Deg.		6½ Deg.		6¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.99	0.10	0.99	0.11	0.99	0.11	0.99	0.12	1
2	1.99	0.21	1.99	0.22	1.99	0.23	1.99	0.24	2
3	2.98	0.31	2.98	0.33	2.98	0.34	2.98	0.35	3
4	3.98	0.41	3.98	0.44	3.97	0.45	3.97	0.47	4
5	4.97	0.52	4.97	0.54	4.97	0.57	4.97	0.59	5
6	5.97	0.63	5.96	0.65	5.96	0.68	5.96	0.71	6
7	6.96	0.73	6.96	0.76	6.96	0.79	6.95	0.82	7
8	7.96	0.84	7.95	0.87	7.95	0.91	7.94	0.94	8
9	8.95	0.94	8.95	0.98	8.94	1.02	8.94	1.06	9
10	9.95	1.05	9.94	1.09	9.94	1.13	9.93	1.18	10
11	10.94	1.15	10.93	1.20	10.93	1.25	10.92	1.29	11
12	11.93	1.25	11.93	1.31	11.92	1.36	11.92	1.41	12
13	12.93	1.36	12.92	1.42	12.92	1.47	12.91	1.53	13
14	13.92	1.46	13.92	1.52	13.91	1.59	13.90	1.65	14
15	14.92	1.57	14.91	1.63	14.90	1.70	14.90	1.76	15
16	15.91	1.67	15.90	1.74	15.90	1.81	15.89	1.88	16
17	16.91	1.78	16.90	1.85	16.89	1.92	16.88	2.00	17
18	17.90	1.88	17.89	1.96	17.88	2.04	17.88	2.12	18
19	18.90	1.99	18.89	2.07	18.88	2.15	18.87	2.23	19
20	19.89	2.09	19.88	2.18	19.87	2.26	19.86	2.35	20
21	20.88	2.20	20.88	2.29	20.87	2.38	20.85	2.47	21
22	21.88	2.30	21.87	2.40	21.86	2.49	21.85	2.59	22
23	22.87	2.40	22.86	2.50	22.85	2.60	22.84	2.70	23
24	23.87	2.51	23.86	2.61	23.85	2.72	23.83	2.82	24
25	24.86	2.61	24.85	2.72	24.84	2.83	24.83	2.94	25
26	25.86	2.72	25.85	2.83	25.83	2.94	25.82	3.06	26
27	26.85	2.82	26.84	2.94	26.83	3.06	26.81	3.17	27
28	27.85	2.93	27.83	3.05	27.82	3.17	27.81	3.29	28
29	28.84	3.03	28.83	3.16	28.81	3.28	28.80	3.41	29
30	29.84	3.14	29.82	3.27	29.81	3.40	29.79	3.53	30
31	30.83	3.24	30.82	3.37	30.80	3.51	30.79	3.64	31
32	31.82	3.34	31.81	3.48	31.79	3.62	31.78	3.76	32
33	32.82	3.45	32.80	3.59	32.79	3.74	32.77	3.88	33
34	33.81	3.55	33.80	3.70	33.78	3.85	33.76	4.00	34
35	34.81	3.66	34.79	3.81	34.78	3.96	34.76	4.11	35
36	35.80	3.76	35.79	3.92	35.77	4.08	35.75	4.23	36
37	36.80	3.87	36.78	4.03	36.76	4.19	36.75	4.35	37
38	37.79	3.97	37.77	4.14	37.76	4.30	37.74	4.47	38
39	38.79	4.08	38.77	4.25	38.75	4.41	38.73	4.58	39
40	39.78	4.18	39.76	4.35	39.74	4.53	39.72	4.70	40
41	40.78	4.29	40.76	4.46	40.74	4.64	40.72	4.82	41
42	41.77	4.39	41.75	4.57	41.73	4.76	41.71	4.94	42
43	42.76	4.49	42.74	4.68	42.72	4.87	42.70	5.05	43
44	43.76	4.60	43.74	4.79	43.72	4.98	43.70	5.17	44
45	44.75	4.70	44.73	4.90	44.71	5.09	44.69	5.29	45
46	45.75	4.81	45.73	5.01	45.70	5.21	45.68	5.41	46
47	46.74	4.91	46.72	5.12	46.70	5.32	46.67	5.52	47
48	47.74	5.02	47.71	5.23	47.69	5.43	47.67	5.64	48
49	48.73	5.12	48.71	5.34	48.69	5.55	48.66	5.76	49
50	49.73	5.23	49.70	5.44	49.68	5.66	49.65	5.88	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	84 Deg.		83¾ Deg.		83½ Deg.		83¼ Deg.		

Distance.	6 Deg.		6¼ Deg.		6½ Deg.		6¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lát.	Dep.	
51	50.72	5.33	50.70	5.55	50.67	5.77	50.65	5.99	51
52	51.72	5.44	51.69	5.66	51.67	5.89	51.64	6.11	52
53	52.71	5.54	52.68	5.77	52.66	6.00	52.63	6.23	53
54	53.70	5.64	53.68	5.88	53.65	6.11	53.63	6.35	54
55	54.70	5.75	54.67	5.99	54.65	6.23	54.62	6.46	55
56	55.69	5.85	55.67	6.10	55.64	6.34	55.61	6.58	56
57	56.69	5.96	56.66	6.21	56.63	6.45	56.60	6.70	57
58	57.68	6.06	57.66	6.31	57.63	6.57	57.60	6.82	58
59	58.68	6.17	58.65	6.42	58.62	6.68	58.59	6.93	59
60	59.67	6.27	59.64	6.53	59.61	6.79	59.58	7.05	60
61	60.67	6.38	60.64	6.64	60.61	6.91	60.58	7.17	61
62	61.66	6.48	61.63	6.75	61.60	7.02	61.57	7.29	62
63	62.65	6.59	62.63	6.86	62.60	7.13	62.56	7.40	63
64	63.65	6.69	63.62	6.97	63.59	7.25	63.56	7.52	64
65	64.64	6.79	64.61	7.08	64.58	7.36	64.55	7.64	65
66	65.64	6.90	65.61	7.19	65.58	7.47	65.54	7.76	66
67	66.63	7.00	66.60	7.29	66.57	7.58	66.54	7.88	67
68	67.63	7.11	67.60	7.40	67.56	7.70	67.53	7.99	68
69	68.62	7.21	68.59	7.51	68.56	7.81	68.52	8.11	69
70	69.62	7.32	69.58	7.62	69.55	7.92	69.51	8.23	70
71	70.61	7.42	70.58	7.73	70.54	8.04	70.51	8.35	71
72	71.61	7.53	71.57	7.84	71.54	8.15	71.50	8.46	72
73	72.60	7.63	72.57	7.95	72.53	8.26	72.49	8.58	73
74	73.59	7.74	73.56	8.06	73.52	8.38	73.49	8.70	74
75	74.59	7.84	74.55	8.17	74.52	8.49	74.48	8.82	75
76	75.58	7.94	75.55	8.27	75.51	8.60	75.47	8.93	76
77	76.58	8.05	76.54	8.38	76.51	8.72	76.47	9.05	77
78	77.57	8.15	77.54	8.49	77.50	8.83	77.46	9.17	78
79	78.57	8.26	78.53	8.60	78.49	8.94	78.45	9.29	79
80	79.56	8.36	79.53	8.71	79.49	9.06	79.45	9.40	80
81	80.56	8.47	80.52	8.82	80.48	9.17	80.44	9.52	81
82	81.55	8.57	81.51	8.93	81.47	9.28	81.43	9.64	82
83	82.55	8.68	82.51	9.04	82.47	9.40	82.42	9.76	83
84	83.54	8.78	83.50	9.14	83.46	9.51	83.42	9.87	84
85	84.53	8.88	84.50	9.25	84.45	9.62	84.41	9.99	85
86	85.53	8.99	85.49	9.36	85.45	9.74	85.40	10.11	86
87	86.52	9.09	86.48	9.47	86.44	9.85	86.40	10.23	87
88	87.52	9.20	87.48	9.58	87.43	9.96	87.39	10.34	88
89	88.51	9.30	88.47	9.69	88.43	10.08	88.38	10.46	89
90	89.51	9.41	89.47	9.80	89.42	10.19	89.38	10.58	90
91	90.50	9.51	90.46	9.91	90.42	10.30	90.37	10.70	91
92	91.50	9.62	91.45	10.02	91.41	10.41	91.36	10.81	92
93	92.49	9.72	92.45	10.12	92.40	10.53	92.36	10.93	93
94	93.49	9.83	93.44	10.23	93.40	10.64	93.35	11.05	94
95	94.48	9.93	94.44	10.34	94.39	10.75	94.34	11.17	95
96	95.47	10.03	95.43	10.45	95.38	10.87	95.33	11.28	96
97	96.47	10.14	96.42	10.56	96.38	10.98	96.33	11.40	97
98	97.46	10.24	97.42	10.67	97.37	11.09	97.32	11.52	98
99	98.46	10.35	98.41	10.78	98.36	11.21	98.31	11.64	99
100	99.45	10.45	99.41	10.89	99.36	11.32	99.31	11.75	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	84 Deg.		83¾ Deg.		83½ Deg.		83¼ Deg.		

Distance.	7 Deg.		7¼ Deg.		7½ Deg.		7¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.99	0.12	0.99	0.13	0.99	0.13	0.99	0.13	1
2	1.99	0.24	1.98	0.25	1.98	0.26	1.98	0.27	2
3	2.98	0.37	2.98	0.38	2.97	0.39	2.97	0.40	3
4	3.97	0.49	3.97	0.50	3.97	0.52	3.96	0.54	4
5	4.96	0.61	4.96	0.63	4.96	0.65	4.95	0.67	5
6	5.96	0.73	5.95	0.76	5.95	0.78	5.95	0.81	6
7	6.95	0.85	6.94	0.88	6.94	0.91	6.94	0.94	7
8	7.94	0.97	7.94	1.01	7.93	1.04	7.93	1.08	8
9	8.93	1.10	8.93	1.14	8.92	1.17	8.92	1.21	9
10	9.93	1.22	9.92	1.26	9.91	1.31	9.91	1.35	10
11	10.92	1.34	10.91	1.39	10.91	1.44	10.90	1.48	11
12	11.91	1.46	11.90	1.51	11.90	1.57	11.89	1.62	12
13	12.90	1.58	12.90	1.64	12.89	1.70	12.88	1.75	13
14	13.90	1.71	13.89	1.77	13.88	1.83	13.87	1.89	14
15	14.89	1.83	14.88	1.89	14.87	1.96	14.86	2.02	15
16	15.88	1.95	15.87	2.02	15.86	2.09	15.85	2.16	16
17	16.87	2.07	16.86	2.15	16.85	2.22	16.84	2.29	17
18	17.87	2.19	17.86	2.27	17.85	2.35	17.84	2.43	18
19	18.86	2.32	18.85	2.40	18.84	2.48	18.83	2.56	19
20	19.85	2.44	19.84	2.52	19.83	2.61	19.82	2.70	20
21	20.84	2.56	20.83	2.65	20.82	2.74	20.81	2.83	21
22	21.84	2.68	21.82	2.78	21.81	2.87	21.80	2.97	22
23	22.83	2.80	22.82	2.90	22.80	3.00	22.79	3.10	23
24	23.82	2.92	23 81	3.03	23.79	3.13	23.78	3.24	24
25	24.81	3.05	24.80	3.15	24.79	3.26	24.77	3.37	25
26	25.81	3.17	25.79	3.28	25.78	3.39	25.76	3.51	26
27	26.80	3.29	26.78	3.41	26.77	3.52	26.75	3.64	27
28	27.79	3.41	27.78	3.53	27.76	3.65	27.74	3.78	28
29	28.78	3.53	28.77	3.66	28.75	3.79	28.74	3.91	29
30	29.78	3.66	29.76	3.79	29.74	3.92	29.73	4.05	30
31	30.77	3.78	30.75	3.91	30.73	4.05	30.72	4.18	31
32	31.76	3.90	31.74	4.04	31.73	4.18	31.71	4.32	32
33	32.75	4.02	32.74	4.16	32.72	4.31	32.70	4.45	33
34	33.75	4.14	33.73	4.29	33.71	4.44	33.69	4.58	34
35	34.74	4.27	34.72	4.42	34.70	4.57	34.68	4.72	35
36	35.73	4.39	35.71	4.54	35.69	4.70	35.67	4.85	36
37	36.72	4.51	36.70	4.67	36.68	4.83	36.66	4.99	37
38	37.72	4.63	37.70	4.80	37.67	4.96	37.65	5.12	38
39	38.71	4.75	38.69	4.92	38.67	5.09	38.64	5.26	39
40	39.70	4.87	39.68	5.05	39.66	5.22	39.63	5.39	40
41	40.70	5.00	40.67	5.17	40.65	5.35	40.63	5.53	41
42	41.69	5.12	41.66	5.30	41.64	5.48	41.62	5.66	42
43	42.68	5.24	42.66	5.43	42.63	5.61	42.61	5.80	43
44	43.67	5.36	43.65	5.55	43.62	5.74	43.60	5.93	44
45	44.67	5.48	44.64	5.68	44.62	5.87	44.59	6.07	45
46	45.66	5.61	45.63	5.81	45.61	6.00	45.58	6.20	46
47	46.65	5.73	46.62	5.93	46.60	6.13	46.57	6.34	47
48	47.64	5.85	47.62	6.06	47.59	6.27	47.56	6.47	48
49	48.63	5.97	48.61	6.18	48.58	6.40	48.55	6.61	49
50	49.63	6.09	49.60	6.31	49.57	6.53	49.54	6.74	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	83 Deg.		82¾ Deg.		82½ Deg.		82¼ Deg.		

Distance.	7 Deg.		7¼ Deg.		7½ Deg.		7¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.62	6.22	50.59	6.44	50.56	6.66	50.53	6.88	51
52	51.61	6.34	51.58	6.56	51.56	6.79	51.53	7.01	52
53	52.60	6.46	52.58	6.69	52.55	6.92	52.52	7.15	53
54	53.60	6.58	53.57	6.81	53.54	7.05	53.51	7.28	54
55	54.59	6.70	54.56	6.94	54.53	7.18	54.50	7.42	55
56	55.58	6.82	55.55	7.07	55.52	7.31	55.49	7.55	56
57	56.58	6.95	56.54	7.19	56.51	7.44	56.48	7.69	57
58	57.57	7.07	57.54	7.32	57.50	7.57	57.47	7.82	58
59	58.56	7.19	58.53	7.45	58.50	7.70	58.46	7.96	59
60	59.55	7.31	59.52	7.57	59.49	7.83	59.45	8.09	60
61	60.55	7.43	60.51	7.70	60.48	7.96	60.44	8.23	61
62	61.54	7.56	61.50	7.82	61.47	8.09	61.43	8.36	62
63	62.53	7.68	62.50	7.95	62.46	8.22	62.42	8.50	63
64	63.52	7.80	63.49	8.08	63.45	8.35	63.42	8.63	64
65	64.52	7.92	64.48	8.20	64.44	8.48	64.41	8.77	65
66	65.51	8.04	65.47	8.33	65.44	8.61	65.40	8.90	66
67	66.50	8.17	66.46	8.46	66.43	8.75	66.39	9.04	67
68	67.49	8.29	67.46	8.58	67.42	8.88	67.38	9.17	68
69	68.49	8.41	68.45	8.71	68.41	9.01	68.37	9.30	69
70	69.48	8.53	69.44	8.83	69.40	9.14	69.36	9.44	70
71	[illegible]	8.65	70.43	8.96	70.39	9.27	70.35	9.57	71
72	[illegible]	8.77	71.42	9.09	71.38	9.40	71.34	9.71	72
73	72.46	8.90	72.42	9.21	72.38	9.53	72.33	9.84	73
74	73.45	9.02	73.41	9.34	73.37	9.66	73.32	9.98	74
75	74.44	9.14	74.40	9.46	74.36	9.79	74.31	10.11	75
76	75.43	9.26	75.39	9.59	75.35	9.92	75.31	10.25	76
77	76.43	9.38	76.38	9.72	76.34	10.05	76.30	10.38	77
78	77.42	9.51	77.38	9.84	77.33	10.18	77.29	10.52	78
79	78.41	9.63	78.37	9.97	78.32	10.31	78.28	10.65	79
80	79.40	9.75	79.36	10.10	79.32	10.44	79.27	10.79	80
81	80.40	9.87	80.35	10.22	80.31	10.57	80.26	10.92	81
82	81.39	9.99	81.34	10.35	81.30	10.70	81.25	11.06	82
83	82.38	10.12	82.34	10.47	82.29	10.83	82.24	11.19	83
84	83.37	10.24	83.33	10.60	83.28	10.96	83.23	11.33	84
85	84.37	10.36	84.32	10.73	84.27	11.09	84.22	11.46	85
86	85.36	10.48	85.31	10.85	85.26	11.23	85.21	11.60	86
87	86.35	10.60	86.30	10.98	86.26	11.36	86.21	11.73	87
88	87.34	10.72	87.30	11.11	87.25	11.49	87.20	11.87	88
89	88.34	10.85	88.29	11.23	88.24	11.62	88.19	12.00	89
90	89.33	10.97	89.28	11.36	89.23	11.75	89.18	12.14	90
91	90.32	11.09	90.27	11.48	90.22	11.88	90.17	12.27	91
92	91.31	11.21	91.26	11.61	91.21	12.01	91.16	12.41	92
93	92.31	11.33	92.26	11.74	92.20	12.14	92.15	12.54	93
94	93.30	11.46	93.25	11.86	93.20	12.27	93.14	12.68	94
95	94.29	11.58	94.24	11.99	94.19	12.40	94.13	12.81	95
96	95.28	11.70	95.23	12.12	95.18	12.53	95.12	12.95	96
97	96.28	11.82	96.22	12.24	96.17	12.66	96.11	13.08	97
98	97.27	11.94	97.22	12.37	97.16	12.79	97.10	13.22	98
99	98.26	12.07	98.21	12.49	98.15	12.92	98.10	13.35	99
100	99.25	12.19	99.20	12.62	99.14	13.05	99.09	13.49	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	83 Deg.		82¾ Deg.		82½ Deg.		82¼ Deg.		

Distance.	8 Deg.		8¼ Deg.		8½ Deg.		8¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.99	0.14	0.99	0.14	0.99	0.15	0.99	0.15	1
2	1.98	0.28	1.98	0.29	1.98	0.30	1.98	0.30	2
3	2.97	0.42	2.97	0.43	2.97	0.44	2.97	0.46	3
4	3.96	0.56	3.96	0.57	3.96	0.59	3.95	0.61	4
5	4.95	0.70	4.95	0.72	4.95	0.74	4.94	0.76	5
6	5.94	0.84	5.94	0.86	5.93	0.89	5.93	0.91	6
7	6.93	0.97	6.93	1.00	6.92	1.03	6.92	1.06	7
8	7.92	1.11	7.92	1.15	7.91	1.18	7.91	1.22	8
9	8.91	1.25	8.91	1.29	8.90	1.33	8.90	1.37	9
10	9.90	1.39	9.90	1.43	9.89	1.48	9.88	1.52	10
11	10.89	1.53	10.89	1.58	10.88	1.63	10.87	1.67	11
12	11.88	1.67	11.88	1.72	11.87	1.77	11.86	1.83	12
13	12.87	1.81	12.87	1.87	12.86	1.92	12.85	1.98	13
14	13.86	1.95	13.86	2.01	13.85	2.07	13.84	2.13	14
15	14.85	2.09	14.85	2.15	14.84	2.22	14.83	2.28	15
16	15.84	2.23	15.84	2.30	15.82	2.36	15.81	2.43	16
17	16.83	2.37	16.83	2.44	16.81	2.51	16.80	2.59	17
18	17.82	2.51	17.81	2.58	17.80	2.66	17.79	2.74	18
19	18.82	2.64	18.80	2.73	18.79	2.81	18.78	2.89	19
20	19.81	2.78	19.79	2.87	19.78	2.96	19.77	3.04	20
21	20.80	2.92	20.78	3.01	20.77	3.10	20.76	3.19	21
22	21.79	3.06	21.77	3.16	21.76	3.25	21.74	3.35	22
23	22.78	3.20	22.76	3.30	22.75	3.40	22.73	3.50	23
24	23.77	3.34	23.75	3.44	23.74	3.55	23.72	3.65	24
25	24.76	3.48	24.74	3.59	24.73	3.70	24.71	3.80	25
26	25.75	3.62	25.73	3.73	25.71	3.84	25.70	3.96	26
27	26.74	3.76	26.72	3.87	26.70	3.99	26.69	4.11	27
28	27.73	3.90	27.71	4.02	27.69	4.14	27.67	4.26	28
29	28.72	4.04	28.70	4.16	28.68	4.29	28.66	4.41	29
30	29.71	4.18	29.69	4.30	29.67	4.43	29.65	4.56	30
31	30.70	4.31	30.68	4.45	30.66	4.58	30.64	4.72	31
32	31.69	4.45	31.67	4.59	31.65	4.73	31.63	4.87	32
33	32.68	4.59	32.66	4.74	32.64	4.88	32.62	5.02	33
34	33.67	4.73	33.65	4.88	33.63	5.03	33.60	5.17	34
35	34.66	4.87	34.64	5.02	34.62	5.17	34.59	5.32	35
36	35.65	5.01	35.63	5.17	35.60	5.32	35.58	5.48	36
37	36.64	5.15	36.62	5.31	36.59	5.47	36.57	5.63	37
38	37.63	5.29	37.61	5.45	37.58	5.62	37.56	5.78	38
39	38.62	5.43	38.60	5.60	38.57	5.76	38.55	5.93	39
40	39.61	5.57	39.59	5.74	39.56	5.91	39.53	6.08	40
41	40.60	5.71	40.58	5.88	40.55	6.06	40.52	6.24	41
42	41.59	5.85	41.57	6.03	41.54	6.21	41.51	6.39	42
43	42.58	5.98	42.56	6.17	42.53	6.36	42.50	6.54	43
44	43.57	6.12	43.54	6.31	43.52	6.50	43.49	6.69	44
45	44.56	6.26	44.53	6.46	44.51	6.65	44.48	6.85	45
46	45.55	6.40	45.52	6.60	45.49	6.80	45.46	7.00	46
47	46.54	6.54	46.51	6.74	46.48	6.95	46.45	7.15	47
48	47.53	6.68	47.50	6.89	47.47	7.09	47.44	7.30	48
49	48.52	6.82	48.49	7.03	48.46	7.24	48.43	7.45	49
50	49.51	6.96	49.48	7.17	49.45	7.39	49.42	7.61	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	82 Deg.		81¾ Deg.		81½ Deg.		81¼ Deg.		

Distance.	8 Deg.		8¼ Deg.		8½ Deg.		8¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.50	7.10	50.47	7.32	50.44	7.54	50.41	7.76	51
52	51.49	7.24	51.46	7.46	51.43	7.69	51.39	7.91	52
53	52.48	7.38	52.45	7.61	52.42	7.83	52.38	8.06	53
54	53.47	7.52	53.44	7.75	53.41	7.98	53.37	8.21	54
55	54.46	7.65	54.43	7.89	54.40	8.13	54.36	8.37	55
56	55.46	7.79	55.42	8.04	55.38	8.28	55.35	8.52	56
57	56.45	7.93	56.41	8.18	56.37	8.43	56.34	8.67	57
58	57.44	8.07	57.40	8.32	57.36	8.57	57.32	8.82	58
59	58.43	8.21	58.39	8.47	58.35	8.72	58.31	8.98	59
60	59.42	8.35	59.38	8.61	59.34	8.87	59.30	9.13	60
61	60.41	8.49	60.37	8.75	60.33	9.02	60.29	9.28	61
62	61.40	8.63	61.36	8.90	61.32	9.16	61.28	9.43	62
63	62.39	8.77	62.35	9.04	62.31	9.31	62.27	9.58	63
64	63.38	8.91	63.34	9.18	63.30	9.46	63.26	9.74	64
65	64.37	9.05	64.33	9.33	64.29	9.61	64.24	9.89	65
66	65.36	9.19	65.32	9.47	65.28	9.76	65.23	10.04	66
67	66.35	9.32	66.31	9.61	66.26	9.90	66.22	10.19	67
68	67.34	9.46	67.30	9.76	67.25	10.05	67.21	10.34	68
69	68.33	9.60	68.29	9.90	68.24	10.20	68.20	10.50	69
70	69.32	9.74	69.28	10.04	69.23	10.35	69.19	10.65	70
71	70.31	9.88	70.27	10.19	70.22	10.49	70.17	10.80	71
72	71.30	10.02	71.25	10.33	71.21	10.64	71.16	10.95	72
73	72.29	10.16	72.24	10.47	72.20	10.79	72.15	11.10	73
74	73.28	10.30	73.23	10.62	73.19	10.94	73.14	11.26	74
75	74.27	10.44	74.22	10.76	74.18	11.09	74.13	11.41	75
76	75.26	10.58	75.21	10.91	75.17	11.23	75.12	11.56	76
77	76.25	10.72	76.20	11.05	76.15	11.38	76.10	11.71	77
78	77.24	10.86	77.19	11.19	77.14	11.53	77.09	11.87	78
79	78.23	10.99	78.18	11.34	78.13	11.68	78.08	12.02	79
80	79.22	11.13	79.17	11.48	79.12	11.82	79.07	12.17	80
81	80.21	11.27	80.16	11.62	80.11	11.97	80.06	12.32	81
82	81.20	11.41	81.15	11.77	81.10	12.12	81.05	12.47	82
83	82.19	11.55	82.14	11.91	82.09	12.27	82.03	12.63	83
84	83.18	11.69	83.13	12.05	83.08	12.42	83.02	12.78	84
85	84.17	11.83	84.12	12.20	84.07	12.56	84.01	12.93	85
86	85.16	11.97	85.11	12.34	85.06	12.71	85.00	13.08	86
87	86.15	12.11	86.10	12.48	86.04	12.86	85.99	13.23	87
88	87.14	12.25	87.09	12.63	87.03	13.01	86.98	13.39	88
89	88.13	12.39	88.08	12.77	88.02	13.16	87.96	13.54	89
90	89.12	12.53	89.07	12.91	89.01	13.30	88.95	13.69	90
91	90.11	12.66	90.06	13.06	90.00	13.45	89.94	13.84	91
92	91.10	12.80	91.05	13.20	90.99	13.60	90.93	14.00	92
93	92.09	12.94	92.04	13.34	91.98	13.75	91.92	14.15	93
94	93.09	13.08	93.03	13.49	92.97	13.89	92.91	14.30	94
95	94.08	13.22	94.02	13.63	93.96	14.04	93.89	14.45	95
96	95.07	13.36	95.01	13.78	94.95	14.19	94.88	14.60	96
97	96.06	13.50	96.00	13.92	95.93	14.34	95.87	14.76	97
98	97.05	13.64	96.99	14.06	96.92	14.49	96.86	14.91	98
99	98.04	13.78	97.98	14.21	97.91	14.63	97.85	15.06	99
100	99.03	13.92	98.97	14.35	98.90	14.78	98.84	15.21	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	82 Deg.		81¾ Deg.		81½ Deg.		81¼ Deg.		

Distance.	9 Deg.		9¼ Deg.		9½ Deg.		9¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.99	0.16	0.99	0.16	0.99	0.17	0.99	0.17	1
2	1.98	0.31	1.97	0.32	1.97	0.33	1.97	0.34	2
3	2.96	0.47	2.96	0.48	2.96	0.50	2.96	0.51	3
4	3.95	0.63	3.95	0.64	3.95	0.66	3.94	0.68	4
5	4.94	0.78	4.93	0.80	4.93	0.83	4.93	0.85	5
6	5.93	0.94	5.92	0.96	5.92	0.99	5.91	1.02	6
7	6.91	1.10	6.91	1.13	6.90	1.16	6.90	1.19	7
8	7.90	1.25	7.90	1.29	7.89	1.32	7.88	1.35	8
9	8.89	1.41	8.88	1.45	8.88	1.49	8.87	1.52	9
10	9.88	1.56	9.87	1.61	9.86	1.65	9.86	1.69	10
11	10.86	1.72	10.86	1.77	10.85	1.82	19.84	1.86	11
12	11.85	1.88	11.84	1.93	11.84	1.98	11.83	2.03	12
13	12.84	2.03	12.83	2.09	12.82	2.15	12.81	2.20	13
14	13.83	2.19	13.82	2.25	13.81	2.31	13.80	2.37	14
15	14.82	2.35	14.80	2.41	14.79	2.48	14.78	2.54	15
16	15.80	2.50	15.79	2.57	15.78	2.64	15.77	2.71	16
17	16.79	2.66	16.78	2.73	16.77	2.81	16.75	2.88	17
18	17.78	2.82	17.77	2.89	17.75	2.97	17.74	3.05	18
19	18.77	2.97	18.75	3.05	18.74	3.14	18.73	3.22	19
20	19.75	3.13	19.74	3.21	19.73	3.30	19.71	3.39	20
21	20.74	3.29	20.73	3.38	20.71	3.47	20.70	3.56	21
22	21.73	3.44	21.71	3.54	21.70	3.63	21.68	3.73	22
23	22.72	3.60	22.70	3.70	22.68	3.80	22.67	3.90	23
24	23.70	3.75	23.69	3.86	23.67	3.96	23.65	4.06	24
25	24.69	3.91	24.67	4.02	24.66	4.13	24.64	4.23	25
26	25.68	4.07	25.66	4.18	25.64	4.29	25.62	4.40	26
27	26.67	4.22	26.65	4.34	26.63	4.46	26.61	4.57	27
28	27.66	4.38	27.64	4.50	27.62	4.62	27.60	4.74	28
29	28.64	4.54	28.62	4.66	28.60	4.79	28.58	4.91	29
30	29.63	4.69	29.61	4.82	29.59	4.95	29.57	5.08	30
31	30.62	4.85	30.60	4.98	30.57	5.12	30.55	5.25	31
32	31.61	5.01	31.58	5.14	31.56	5.28	31.54	5.42	32
33	32.59	5.16	32.57	5.30	32.55	5.45	32.52	5.59	33
34	33.58	5.32	33.56	5.47	33.53	5.61	33.51	5.76	34
35	34.57	5.48	34.54	5.63	34.52	5.78	34.49	5.93	35
36	35.56	5.63	35.53	5.79	35.51	5.94	35.48	6.10	36
37	36.54	5.79	36.52	5.95	36.49	6.11	36.47	6.27	37
38	37.53	5.94	37.51	6.11	37.48	6.27	37.45	6.44	38
39	38.52	6.10	38.49	6.27	38.47	6.44	38.44	6.60	39
40	39.51	6.26	39.48	6.43	39.45	6.60	39.42	6.77	40
41	40.50	6.41	40.47	6.59	40.44	6.77	40.41	6.94	41
42	41.48	6.57	41.45	6.75	41.42	6.92	41.39	7.11	42
43	42.47	6.73	42.44	6.91	42.41	7.10	42.38	7.28	43
44	43.46	6.88	43.43	7.07	43.40	7.26	43.36	7.45	44
45	44.45	7.04	44.41	7.23	44.38	7.43	44.35	7.62	45
46	45.43	7.20	45.40	7.39	45.37	7.59	45.34	7.79	46
47	46.42	7.35	46.39	7.55	46.36	7.76	46.32	7.96	47
48	47.41	7.51	47.38	7.72	47.34	7.92	47.31	8.13	48
49	48.40	7.67	48.36	7.88	48.33	8.09	48.29	8.30	49
50	49.38	7.82	49.35	8.04	49.32	8.25	49.28	8.47	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	81 Deg.		80¾ Deg.		80½ Deg.		80¼ Deg.		

Distance.	9 Deg.		9¼ Deg.		9½ Deg.		9¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.37	7.98	50.34	8.20	50.30	8.42	50.26	8.64	51
52	51.36	8.13	51.32	8.36	51.29	8.58	51.25	8.81	52
53	52.35	8.29	52.31	8.52	52.27	8.75	52.23	8.98	53
54	53.34	8.45	53.30	8.68	53.26	8.91	53.22	9.14	54
55	54.32	8.60	54.28	8.84	54.25	9.08	54.21	9.31	55
56	55.31	8.76	55.27	9.00	55.23	9.24	55.19	9.48	56
57	56.30	8.92	56.26	9.16	56.22	9.41	56.18	9.65	57
58	57.29	9.07	57.25	9.32	57.20	9.57	57.16	9.82	58
59	58.27	9.23	58.23	9.48	58.19	9.74	58.15	9.99	59
60	59.26	9.39	59.22	9.64	59.18	9.90	59.13	10.16	60
61	60.25	9.54	60.21	9.81	60.16	10.07	60.12	10.33	61
62	61.24	9.70	61.19	9.97	61.15	10.23	61.10	10.50	62
63	62.22	9.86	62.18	10.13	62.14	10.40	62.09	10.67	63
64	63.21	10.01	63.17	10.29	63.12	10.56	63.08	10.84	64
65	64.20	10.17	64.15	10.45	64.11	10.73	64.06	11.01	65
66	65.19	10.32	65.14	10.61	65.09	10.89	65.05	11.18	66
67	66.18	10.48	66.13	10.77	66.08	11.06	66.03	11.35	67
68	67.16	10.64	67.12	10.93	67.07	11.22	67.02	11.52	68
69	68.15	10.79	68.10	11.09	68.05	11.39	68.00	11.69	69
70	69.14	10.95	69.09	11.25	69.04	11.55	68.99	11.85	70
71	70.13	11.11	70.08	11.41	70.03	11.72	69.97	12.02	71
72	71.11	11.26	71.06	11.57	71.01	11.88	70.96	12.19	72
73	72.10	11.42	72.05	11.73	72.00	12.05	71.95	12.36	73
74	73.09	11.58	73.04	11.89	72.99	12.21	72.93	12.53	74
75	74.08	11.73	74.02	12.06	73.97	12.38	73.92	12.70	75
76	75.06	11.89	75.01	12.22	74.96	12.54	74.90	12.87	76
77	76.05	12.05	76.00	12.38	75.94	12.71	75.89	13.04	77
78	77.04	12.20	76.99	12.54	76.93	12.87	76.87	13.21	78
79	78.03	12.36	77.97	12.70	77.92	13.04	77.86	13.38	79
80	79.02	12.51	78.96	12.86	78.90	13.20	78.84	13.55	80
81	80.00	12.67	79.95	13.02	79.89	13.37	79.83	13.72	81
82	80.99	12.83	80.93	13.18	80.88	13.53	80.82	13.89	82
83	81.98	12.98	81.92	13.34	81.86	13.70	81.80	14.06	83
84	82.97	13.14	82.91	13.50	82.85	13.86	82.79	14.23	84
85	83.95	13.30	83.89	13.66	83.83	14.03	83.77	14.39	85
86	84.94	13.45	84.88	13.82	84.82	14.19	84.76	14.56	86
87	85.93	13.61	85.87	13.98	85.81	14.36	85.74	14.73	87
88	86.92	13.77	86.86	14.15	86.79	14.52	86.73	14.90	88
89	87.90	13.92	87.84	14.31	87.78	14.69	87.71	15.07	89
90	88.89	14.08	88.83	14.47	88.77	14.85	88.70	15.24	90
91	89.88	14.24	89.82	14.63	89.75	15.02	89.69	15.41	91
92	90.87	14.39	90.80	14.79	90.74	15.18	90.67	15.58	92
93	91.86	14.55	91.79	14.95	91.72	15.35	91.66	15.75	93
94	92.84	14.70	92.78	15.11	92.71	15.51	92.64	15.92	94
95	93.83	14.86	93.76	15.27	93.70	15.68	93.63	16.09	95
96	94.82	15.02	94.75	15.43	94.68	15.84	94.61	16.26	96
97	95.81	15.17	95.74	15.59	95.67	16.01	95.60	16.43	97
98	96.79	15.33	96.73	15.75	96.66	16.17	96.58	16.60	98
99	97.78	15.49	97.71	15.91	97.64	16.34	97.57	16.77	99
100	98.77	15.64	98.70	16.07	98.63	16.50	98.56	16.93	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	81 Deg.		80¾ Deg.		80½ Deg.		80¼ Deg.		

Distance.	11 Deg.		11¼ Deg.		11½ Deg.		11¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.98	0.19	0.98	0.20	0.98	0.20	0.98	0.20	1
2	1.96	0.38	1.96	0.39	1.96	0.40	1.96	0.41	2
3	2.94	0.57	2.94	0.59	2.94	0.60	2.94	0.61	3
4	3.93	0.76	3.92	0.78	3.92	0.80	3.92	0.82	4
5	4.91	0.95	4.90	0.98	4.90	1.00	4.90	1.02	5
6	5.89	1.14	5.88	1.17	5.88	1.20	5.87	1.22	6
7	6.87	1.34	6.87	1.37	6.86	1.40	6.85	1.43	7
8	7.85	1.53	7.85	1.56	7.84	1.59	7.83	1.63	8
9	8.83	1.72	8.83	1.76	8.82	1.79	8.81	1.83	9
10	9.82	1.91	9.81	1.95	9.80	1.99	9.79	2.04	10
11	10.80	2.10	10.79	2.15	10.78	2.19	10.77	2.24	11
12	11.78	2.29	11.77	2.34	11.76	2.39	11.75	2.44	12
13	12.76	2.48	12.75	2.54	12.74	2.59	12.73	2.65	13
14	13.74	2.67	13.73	2.73	13.72	2.79	13.71	2.85	14
15	14.72	2.86	14.71	2.93	14.70	2.99	14.69	3.06	15
16	15.71	3.05	15.69	3.12	15.68	3.19	15.66	3.26	16
17	16.69	3.24	16.67	3.32	16.66	3.39	16.64	3.46	17
18	17.67	3.43	17.65	3.51	17.64	3.59	17.62	3.66	18
19	18.65	3.63	18.63	3.71	18.62	3.79	18.60	3.87	19
20	19.63	3.82	19.62	3.90	19.60	3.99	19.58	4.07	20
21	20.61	4.01	20.60	4.10	20.58	4.19	20.56	4.28	21
22	21.60	4.20	21.58	4.29	21.56	4.39	21.54	4.48	22
23	22.58	4.39	22.56	4.49	22.54	4.59	22.52	4.68	23
24	23.56	4.58	23.54	4.68	23.52	4.78	23.50	4.89	24
25	24.54	4.77	24.52	4.88	24.50	4.98	24.48	5.09	25
26	25.52	4.96	25.50	5.07	25.48	5.18	25.46	5.30	26
27	26.50	5.15	26.48	5.27	26.46	5.38	26.43	5.50	27
28	27.49	5.34	27.46	5.46	27.44	5.58	27.41	5.70	28
29	28.47	5.53	28.44	5.66	28.42	5.78	28.39	5.91	29
30	29.45	5.72	29.42	5.85	29.40	5.98	29.37	6.11	30
31	30.43	5.92	30.40	6.05	30.38	6.18	30.35	6.31	31
32	31.41	6.11	31.39	6.24	31.36	6.38	31.33	6.52	32
33	32.39	6.30	32.37	6.44	32.34	6.58	32.31	6.72	33
34	33.38	6.49	33.35	6.63	33.32	6.78	33.29	6.92	34
35	34.36	6.68	34.33	6.83	34.30	6.98	34.27	7.13	35
36	35.34	6.87	35.31	7.02	35.28	7.18	35.25	7.33	36
37	36.32	7.06	36.29	7.22	36.26	7.38	36.22	7.53	37
38	37.30	7.25	37.27	7.41	37.24	7.58	37.20	7.74	38
39	38.28	7.44	38.25	7.61	38.22	7.78	38.18	7.94	39
40	39.27	7.63	39.23	7.80	39.20	7.97	39.16	8.15	40
41	40.25	7.82	40.21	8.00	40.18	8.17	40.14	8.35	41
42	41.23	8.01	41.19	8.19	41.16	8.37	41.12	8.55	42
43	42.21	8.20	42.17	8.39	42.14	8.57	42.10	8.76	43
44	43.19	8.40	43.15	8.58	43.12	8.77	43.08	8.96	44
45	44.17	8.59	44.14	8.78	44.10	8.97	44.06	9.16	45
46	45.15	8.78	45.12	8.97	45.08	9.17	45.04	9.37	46
47	46.14	8.97	46.10	9.17	46.06	9.37	46.02	9.57	47
48	47.12	9.16	47.08	9.36	47.04	9.57	46.99	9.78	48
49	48.10	9.35	48.06	9.56	48.02	9.77	47.97	9.98	49
50	49.08	9.54	49.04	9.75	49.00	9.97	48.95	10.18	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	79 Deg.		78¾ Deg.		78½ Deg.		78¼ Deg.		

Distance.	11 Deg.		11¼ Deg.		11½ Deg.		11¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	50.06	9.73	50.02	9.95	49.98	10.17	49.93	10.39	51
52	51.04	9.92	51.00	10.14	50.96	10.37	50.91	10.59	52
53	52.03	10.11	51.98	10.34	51.94	10.57	51.89	10.79	53
54	53.01	10.30	52.96	10.53	52.92	10.77	52.87	11.00	54
55	53.99	10.49	53.94	10.73	53.90	10.97	53.85	11.20	55
56	54.97	10.69	54.92	10.93	54.88	11.16	54.83	11.40	56
57	55.95	10.88	55.90	11.12	55.86	11.36	55.81	11.61	57
58	56.93	11.07	56.89	11.32	56.84	11.56	56.78	11.81	58
59	57.92	11.26	57.87	11.51	57.82	11.76	57.76	12.01	59
60	58.90	11.45	58.85	11.71	58.80	11.96	58.74	12.22	60
61	58.88	11.64	59.83	11.90	59.78	12.16	59.72	12.42	61
62	60.86	11.83	60.81	12.10	60.76	12.36	60.70	12.63	62
63	61.84	12.02	61.79	12.29	61.74	12.56	61.68	12.83	63
64	62.82	12.21	62.77	12.49	62.72	12.76	62.66	13.03	64
65	63.81	12.40	63.75	12.68	63.70	12.96	63.64	13.24	65
66	64.79	12.59	64.73	12.88	64.68	13.16	64.62	13.44	66
67	65.77	12.78	65.71	13.07	65.66	13.36	65.60	13.64	67
68	66.75	12.98	66.69	13.27	66.63	13.56	66.58	13.85	68
69	67.73	13.17	67.67	13.46	67.61	13.76	67.55	14.05	69
70	68.71	13.36	68.66	13.66	68.59	13.96	68.53	14.25	70
71	69.70	13.55	69.64	13.85	69.57	14.16	69.51	14.46	71
72	70.68	13.74	70.62	14.05	70.55	14.35	70.49	14.66	72
73	71.66	13.93	71.60	14.24	71.53	14.55	71.47	14.87	73
74	72.64	14.12	72.58	14.44	72.51	14.75	72.45	15.07	74
75	73.62	14.31	73.56	14.63	73.49	14.95	73.43	15.27	75
76	74.60	14.50	74.54	14.83	74.47	15.15	74.41	15.48	76
77	75.59	14.69	75.52	15.02	75.45	15.35	75.39	15.68	77
78	76.57	14.88	76.50	15.22	76.43	15.55	76.37	15.88	78
79	77.55	15.07	77.48	15.41	77.41	15.75	77.34	16.09	79
80	78.53	15.26	78.46	15.61	78.39	15.95	78.32	16.29	80
81	79.51	15.46	79.44	15.80	79.37	16.15	79.30	16.49	81
82	80.49	15.65	80.42	16.00	80.35	16.35	80.28	16.70	82
83	81.48	15.84	81.41	16.19	81.33	16.55	81.26	16.90	83
84	82.46	16.03	82.39	16.39	82.31	16.75	82.24	17.11	84
85	83.44	16.22	83.37	16.58	83.29	16.95	83.22	17.31	85
86	84.42	16.41	84.35	16.78	84.27	17.15	84.20	17.51	86
87	85.40	16.60	85.33	16.97	85.25	17.35	85.18	17.72	87
88	86.38	16.79	86.31	17.17	86.23	17.54	86.16	17.92	88
89	87.36	16.98	87.29	17.36	87.21	17.74	87.14	18.12	89
90	88.35	17.17	88.27	17.56	88.19	17.94	88.11	18.33	90
91	89.33	17.36	89.25	17.75	89.17	18.14	89.09	18.53	91
92	90.31	17.55	90.23	17.95	90.15	18.34	90.07	18.74	92
93	91.29	17.75	91.21	18.14	91.13	18.54	91.05	18.94	93
94	92.27	17.94	92.19	18.34	92.11	18.74	92.03	19.14	94
95	93.25	18.13	93.17	18.53	93.09	18.94	93.01	19.35	95
96	94.24	18.32	94.16	18.73	94.07	19.14	93.99	19.55	96
97	95.22	18.51	95.14	18.92	95.05	19.34	94.97	19.75	97
98	96.20	18.70	96.12	19.12	96.03	19.54	95.95	19.96	98
99	97.18	18.89	97.10	19.31	97.01	19.74	96.93	20.16	99
100	98.16	19.08	98.08	19.51	97.99	19.94	97.90	20.36	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	79 Deg.		78¾ Deg.		78½ Deg.		78¼ Deg.		

Distance.	12 Deg.		12¼ Deg.		12½ Deg.		12¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.98	0.21	0.98	0.21	0.98	0.22	0.98	0.22	1
2	1.96	0.42	1.95	0.42	1.95	0.43	1.95	0.44	2
3	2.93	0.62	2.93	0.64	2.93	0.65	2.93	0.66	3
4	3.91	0.83	3.91	0.85	3.91	0.87	3.90	0.88	4
5	4.89	1.04	4.89	1.06	4.88	1.08	4.88	1.10	5
6	5.87	1.25	5.86	1.27	5.86	1.30	5.85	1.32	6
7	6.85	1.46	6.84	1.49	6.83	1.52	6.83	1.54	7
8	7.83	1.66	7.82	1.70	7.81	1.73	7.80	1.77	8
9	8.80	1.87	8.80	1.91	8.79	1.95	8.78	1.99	9
10	9.78	2.08	9.77	2.12	9.76	2.16	9.75	2.21	10
11	10.76	2.29	10.75	2.33	10.74	2.38	10.73	2.43	11
12	11.74	2.49	11.73	2.55	11.72	2.60	11.70	2.65	12
13	12.72	2.70	12.70	2.76	12.69	2.81	12.68	2.87	13
14	13.69	2.91	13.68	2.97	13.67	3.03	13.65	3.09	14
15	14.67	3.12	14.66	3.18	14.64	3.25	14.63	3.31	15
16	15.65	3.33	15.64	3.39	15.62	3.46	15.61	3.53	16
17	16.63	3.53	16.61	3.61	16.60	3.68	16.58	3.75	17
18	17.61	3.74	17.59	3.82	17.57	3.90	17.56	3.97	18
19	18.58	3.95	18.57	4.03	18.55	4.11	18.53	4.19	19
20	19.56	4.16	19.54	4.24	19.53	4.33	19.51	4.41	20
21	20.54	4.37	20.52	4.46	20.50	4.55	20.48	4.63	21
22	21.52	4.57	21.50	4.67	21.48	4.76	21.46	4.86	22
23	22.50	4.78	22.48	4.88	22.45	4.98	22.43	5.08	23
24	23.48	4.99	23.45	5.09	23.43	5.19	23.41	5.30	24
25	24.45	5.20	24.43	5.30	24.41	5.41	24.38	5.52	25
26	25.43	5.41	25.41	5.52	25.38	5.63	25.36	5.74	26
27	26.41	5.61	26.39	5.73	26.36	5.84	26.33	5.96	27
28	27.39	5.82	27.36	5.94	27.34	6.06	27.31	6.18	28
29	28.37	6.03	28.34	6.15	28.31	6.28	28.28	6.40	29
30	29.34	6.24	29.32	6.37	29.29	6.49	29.26	6.62	30
31	30.32	6.45	30.29	6.58	30.27	6.71	30.24	6.84	31
32	31.30	6.65	31.27	6.79	31.24	6.93	31.21	7.06	32
33	32.28	6.86	32.25	7.00	32.22	7.14	32.19	7.28	33
34	33.26	7.07	33.23	7.21	33.19	7.36	33.16	7.50	34
35	34.24	7.28	34.20	7.43	34.17	7.58	34.14	7.72	35
36	35.21	7.48	35.18	7.64	35.15	7.79	35.11	7.95	36
37	36.19	7.69	36.16	7.85	36.12	8.01	36.09	8.17	37
38	37.17	7.90	37.13	8.06	37.10	8.22	37.06	8.39	38
39	38.15	8.11	38.11	8.27	38.08	8.44	38.04	8.61	39
40	39.13	8.32	39.09	8.49	39.05	8.66	39.01	8.83	40
41	40.10	8.52	40.07	8.70	40.03	8.87	39.99	9.05	41
42	41.08	8.73	41.04	8.91	41.00	9.09	40.96	9.27	42
43	42.06	8.94	42.02	9.12	41.98	9.31	41.94	9.49	43
44	43.04	9.15	43.00	9.34	42.96	9.52	42.92	9.71	44
45	44.02	9.36	43.98	9.55	43.93	9.74	43.89	9.93	45
46	44.99	9.56	44.95	9.76	44.91	9.96	44.87	10.15	46
47	45.97	9.77	45.93	9.97	45.89	10.17	45.84	10.37	47
48	46.95	9.98	46.91	10.18	46.86	10.39	46.82	10.59	48
49	47.93	10.19	47.88	10.40	47.84	10.61	47.79	10.81	49
50	48.91	10.40	48.86	10.61	48.81	10.82	48.77	11.03	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	78 Deg.		77¾ Deg.		77½ Deg.		77¼ Deg.		

Distance.	12 Deg.		12¼ Deg.		12½ Deg.		12¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	49.89	10.60	49.84	10.82	49.79	11.04	49.74	11.26	51
52	50.86	10.81	50.82	11.03	50.77	11.25	50.72	11.48	52
53	51.84	11.02	51.79	11.25	51.74	11.47	51.69	11.70	53
54	52.82	11.23	52.77	11.46	52.72	11.69	52.67	11.92	54
55	53.80	11.44	53.75	11.67	53.70	11.90	53.64	12.14	55
56	54.78	11.64	54.72	11.88	54.67	12.12	54.62	12.36	56
57	55.75	11.85	55.70	12.09	55.65	12.34	55.59	12.58	57
58	56.73	12.06	56.68	12.31	56.63	12.55	56.57	12.80	58
59	57.71	12.27	57.66	12.52	57.60	12.77	57.55	13.02	59
60	58.69	12.47	58.63	12.73	58.58	12.99	58.52	13.24	60
61	59.67	12.68	59.61	12.94	59.55	13.20	59.50	13.46	61
62	60.65	12.89	60.59	13.16	60.53	13.42	60.47	13.68	62
63	61.62	13.10	61.57	13.37	61.51	13.64	61.45	13.90	63
64	62.60	13.31	62.54	13.58	62.48	13.85	62.42	14.12	64
65	63.58	13.51	63.52	13.79	63.46	14.07	63.40	14.35	65
66	64.56	13.72	64.50	14.00	64.44	14.29	64.37	14.57	66
67	65.54	13.93	65.47	14.22	65.41	14.50	65.35	14.79	67
68	66.51	14.14	66.45	14.43	66.39	14.72	66.32	15.01	68
69	67.49	14.35	67.43	14.64	67.36	14.93	67.30	15.23	69
70	68.47	14.55	68.41	14.85	68.34	15.15	68.27	15.45	70
71	69.45	14.76	69.38	15.06	69.32	15.37	69.25	15.67	71
72	70.43	14.97	70.36	15.28	70.29	15.58	70.22	15.89	72
73	71.40	15.18	71.34	15.49	71.27	15.80	71.20	16.11	73
74	72.38	15.39	72.32	15.70	72.25	16.02	72.18	16.33	74
75	73.36	15.59	73.29	15.91	73.22	16.23	73.15	16.55	75
76	74.34	15.80	74.27	16.13	74.20	16.45	74.13	16.77	76
77	75.32	16.01	75.25	16.34	75.17	16.67	75.10	16.99	77
78	76.30	16.22	76.22	16.55	76.15	16.88	76.08	17.21	78
79	77.27	16.43	77.20	16.76	77.13	17.10	77.05	17.44	79
80	78.25	16.63	78.18	16.97	78.10	17.32	78.03	17.66	80
81	79.23	16.84	79.16	17.19	79.08	17.53	79.00	17.88	81
82	80.21	17.05	80.13	17.40	80.06	17.75	79.98	18.10	82
83	81.19	17.26	81.11	17.61	81.03	17.96	80.95	18.32	83
84	82.16	17.46	82.09	17.82	82.01	18.18	81.93	18.54	84
85	83.14	17.67	83.06	18.04	82.99	18.40	82.90	18.76	85
86	84.12	17.88	84.04	18.25	83.96	18.61	83.88	18.98	86
87	85.10	18.09	85.02	18.46	84.94	18.83	84.85	19.20	87
88	86.08	18.30	86.00	18.67	85.91	19.05	85.83	19.42	88
89	87.06	18.50	86.97	18.88	86.89	19.26	86.81	19.64	89
90	88.03	18.71	87.95	19.10	87.87	19.48	87.78.	19.86	90
91	89.01	18.92	88.93	19.31	88.84	19.70	88.76	20.08	91
92	89.99	19.13	89.91	19.52	89.82	19.91	89.73	20.30	92
93	90.97	19.34	90.88	19.73	90.80	20.13	90.71	20.52	93
94	91.95	19.54	91.86	19.94	91.77	20.35	91.68	20.75	94
95	92.92	19.75	92.84	20.16	92.75	20.56	92.66	20.97	95
96	93.90	19.96	93.81	20.37	93.72	20.78	93.63	21.19	96
97	94.88	20.17	94.79	20.58	94.70	20.99	94.61	21.41	97
98	95.86	20.38	95.77	20.79	95.68	21.21	95.58	21.63	98
99	96.84	20.58	96.75	21.01	96.65	21.43	96.56	21.85	99
100	97.81	20.79	97.72	21.22	97.63	21.64	97.53	22.07	100
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Distance.	78 Deg.		77¾ Deg.		77½ Deg.		77¼ Deg.		Distance.

Distance.	13 Deg.		13¼ Deg.		13½ Deg.		13¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.97	0.23	0.97	0.23	0.97	0.23	0.97	0.24	1
2	1.95	0.45	1.95	0.46	1.95	0.47	1.94	0.48	2
3	2.92	0.67	2.92	0.69	2.92	0.70	2.91	0.71	3
4	3.90	0.90	3.89	0.92	3.89	0.93	3.89	0.95	4
5	4.87	1.12	4.87	1.15	4.86	1.17	4.86	1.19	5
6	5.85	1.35	5.84	1.38	5.83	1.40	5.83	1.43	6
7	6.82	1.57	6.81	1.60	6.81	1.63	6.80	1.66	7
8	7.80	1.80	7.79	1.83	7.78	1.87	7.77	1.90	8
9	8.77	2.02	8.76	2.06	8.75	2.10	8.74	2.14	9
10	9.74	2.25	9.73	2.29	9.72	2.33	9.71	2.38	10
11	10.72	2.47	10.71	2.52	10.70	2.57	10.68	2.61	11
12	11.69	2.70	11.68	2.75	11.67	2.80	11.66	2.85	12
13	12.67	2.92	12.65	2.98	12.64	3.03	12.63	3.09	13
14	13.64	3.15	13.63	3.21	13.61	3.27	13.60	3.33	14
15	14.62	3.37	14.60	3.44	14.59	3.50	14.57	3.57	15
16	15.59	3.60	15.57	3.67	15.56	3.74	15.54	3.80	16
17	16.57	3.82	16.55	3.90	16.53	3.97	16.51	4.04	17
18	17.54	4.05	17.52	4.13	17.50	4.20	17.48	4.28	18
19	18.51	4.27	18.49	4.35	18.48	4.44	18.46	4.52	19
20	19.49	4.50	19.47	4.58	19.45	4.67	19.43	4.75	20
21	20.46	4.72	20.44	4.81	20.42	4.90	20.40	4.99	21
22	21.44	4.95	21.41	5.04	21.39	5.14	21.37	5.23	22
23	22.41	5.17	22.39	5.27	22.36	5.37	22.34	5.47	23
24	23.38	5.40	23.36	5.50	23.34	5.60	23.31	5.70	24
25	24.36	5.62	24.33	5.73	24.31	5.84	24.28	5.94	25
26	25.33	5.85	25.31	5.96	25.28	6.07	25.25	6.18	26
27	26.31	6.07	26.28	6.19	26.25	6.30	26.23	6.42	27
28	27.28	6.30	27.25	6.42	27.23	6.54	27.20	6.66	28
29	28.26	6.52	28.23	6.65	28.20	6.77	28.17	6.89	29
30	29.23	6.75	29.20	6.88	29.17	7.00	29.14	7.13	30
31	30.21	6.97	30.17	7.11	30.14	7.24	30.11	7.37	31
32	31.18	7.20	31.15	7.33	31.12	7.47	31.08	7.61	32
33	32.15	7.42	32.12	7.56	32.09	7.70	32.05	7.84	33
34	33.13	7.65	33.09	7.79	33.06	7.94	33.03	8.08	34
35	34.10	7.87	34.07	8.02	34.03	8.17	34.00	8.32	35
36	35.08	8.10	35.04	8.25	35.01	8.40	34.97	8.56	36
37	36.05	8.32	36.02	8.48	35.98	8.64	35.94	8.79	37
38	37.03	8.55	36.99	8.71	36.95	8.87	36.91	9.03	38
39	38.00	8.77	37.96	8.94	37.92	9.10	37.88	9.27	39
40	38.97	9.00	38.94	9.17	38.89	9.34	38.85	9.51	40
41	39.95	9.22	39.91	9.40	39.87	9.57	39.83	9.75	41
42	40.92	9.45	40.88	9.63	40.84	9.80	40.80	9.98	42
43	41.90	9.67	41.86	9.86	41.81	10.04	41.77	10.22	43
44	42.87	9.90	42.83	10.08	42.78	10.27	42.74	10.46	44
45	43.85	10.12	43.80	10.31	43.76	10.51	43.71	10.70	45
46	44.82	10.35	44.78	10.54	44.73	10.74	44.68	10.93	46
47	45.80	10.57	45.75	10.77	45.70	10.97	45.65	11.17	47
48	46.77	10.80	46.72	11.00	46.67	11.21	46.62	11.41	48
49	47.74	11.02	47.70	11.23	47.65	11.44	47.60	11.65	49
50	48.72	11.25	48.67	11.46	48.62	11.67	48.57	11.88	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	77 Deg.		76¾ Deg.		76½ Deg.		76¼ Deg.		

Distance.	13 Deg.		13¼ Deg.		13½ Deg.		13¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	49.69	11.47	49.64	11.69	49.59	11.91	49.54	12.12	51
52	50.67	11.70	50.62	11.92	50.56	12.14	50.51	12.36	52
53	51.64	11.92	51.59	12.15	51.54	12.37	51.48	12.60	53
54	52.62	12.15	52.56	12.38	52.51	12.61	52.45	12.84	54
55	53.59	12.37	53.54	12.61	53.48	12.84	53.42	13.07	55
56	54.56	12.60	54.51	12.84	54.45	13.07	54.40	13.31	56
57	55.54	12.82	55.48	13.06	55.43	13.31	55.37	13.55	57
58	56.51	13.05	56.46	13.29	56.40	13.54	56.34	13.79	58
59	57.49	13.27	57.43	13.52	57.37	13.77	57.31	14.02	59
60	58.46	13.50	58.40	13.75	58.34	14.01	58.28	14.26	60
61	59.44	13.72	59.38	13.98	59.31	14.24	59.25	14.50	61
62	60.41	13.95	60.35	14.21	60.29	14.47	60.22	14.74	62
63	61.39	14.17	61.32	14.44	61.26	14.71	61.19	14.97	63
64	62.36	14.40	62.30	14.67	62.23	14.94	62.17	15.21	64
65	63.33	14.62	63.27	14.90	63.20	15.17	63.14	15.45	65
66	64.31	14.85	64.24	15.13	64.18	15.41	64.11	15.69	66
67	65.28	15.07	65.22	15.36	65.15	15.64	65.08	15.93	67
68	66.26	15.30	66.19	15.59	66.12	15.87	66.05	16.16	68
69	67.23	15.52	67.16	15.81	67.09	16.11	67.02	16.40	69
70	68.21	15.75	68.14	16.04	68.07	16.34	67.99	16.64	70
71	69.18	15.97	69.11	16.27	69.04	16.57	68.97	16.88	71
72	70.15	16.20	70.08	16.50	70.01	16.81	69.94	17.11	72
73	71.13	16.42	71.06	16.73	70.98	17.04	70.91	17.35	73
74	72.10	16.65	72.03	16.96	71.96	17.28	71.88	17.59	74
75	73.08	16.87	73.00	17.19	72.93	17.50	72.85	17.83	75
76	74.05	17.10	73.98	17.42	73.90	17.74	73.82	18.06	76
77	75.03	17.32	74.95	17.65	74.87	17.98	74.79	18.30	77
78	76.00	17.55	75.92	17.88	75.84	18.21	75.76	18.54	78
79	76.98	17.77	76.90	18.11	76.82	18.44	76.74	18.78	79
80	77.95	18.00	77.87	18.34	77.79	18.68	77.71	19.01	80
81	78.92	18.22	78.84	18.57	78.76	18.91	78.68	19.25	81
82	79.90	18.45	79.82	18.79	79.73	19.14	79.65	19.49	82
83	80.87	18.67	80.79	19.02	80.71	19.38	80.62	19.73	83
84	81.85	18.90	81.76	19.25	81.68	19.61	81.59	19.97	84
85	82.82	19.12	82.74	19.48	82.65	19.84	82.56	20.20	85
86	83.80	19.35	83.71	19.71	83.62	20.08	83.54	20.44	86
87	84.77	19.57	84.68	19.94	84.60	20.31	84.51	20.68	87
88	85.74	19.80	85.66	20.17	85.57	20.54	85.48	20.92	88
89	86.72	20.02	86.63	20.40	86.54	20.78	86.45	21.15	89
90	87.69	20.25	87.60	20.63	87.51	21.01	87.42	21.39	90
91	88.67	20.47	88.58	20.86	88.49	21.24	88.39	21.63	91
92	89.64	20.70	89.55	21.09	89.46	21.48	89.36	21.87	92
93	90.62	20.92	90.52	21.32	90.43	21.71	90.33	22.10	93
94	91.59	21.15	91.50	21.54	91.40	21.94	91.31	22.34	94
95	92.57	21.37	92.47	21.77	92.38	22.18	92.28	22.58	95
96	93.54	21.60	93.44	22.00	93.35	22.41	93.25	22.82	96
97	94.51	21.82	94.42	22.23	94.32	22.64	94.22	23.06	97
98	95.49	22.05	95.39	22.46	95.29	22.88	95.19	23.29	98
99	96.46	22.27	96.36	22.69	96.26	23.11	96.16	23.53	99
100	97.44	22.50	97.34	22.92	97.24	23.34	97.13	23.77	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	77 Deg.		76¾ Deg.		76½ Deg.		76¼ Deg.		

Distance.	14 Deg.		14¼ Deg.		14½ Deg.		14¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.97	0.24	0.97	0.25	0.97	0.25	0.97	0.25	1
2	1.94	0.48	1.94	0.49	1.94	0.50	1.93	0.51	2
3	2.91	0.73	2.91	0.74	2.90	0.75	2.90	0.76	3
4	3.88	0.97	3.88	0.98	3.87	1.00	3.87	1.02	4
5	4.85	1.21	4.85	1.23	4.84	1.25	4.84	1.27	5
6	5.82	1.45	5.82	1.48	5.81	1.50	5.80	1.53	6
7	6.79	1.69	6.78	1.72	6.78	1.75	6.77	1.78	7
8	7.76	1.94	7.75	1.97	7.75	2.00	7.74	2.04	8
9	8.73	2.18	8.72	2.22	8.71	2.25	8.70	2.29	9
10	9.70	2.42	9.69	2.46	9.68	2.50	9.67	2.55	10
11	10.67	2.66	10.66	2.71	10.65	2.75	10.64	2.80	11
12	11.64	2.90	11.63	2.95	11.62	3.00	11.60	3.06	12
13	12.61	3.15	12.60	3.20	12.59	3.25	12.57	3.31	13
14	13.58	3.39	13.57	3.45	13.55	3.51	13.54	3.56	14
15	14.55	3.63	14.54	3.69	14.52	3.76	14.51	3.82	15
16	15.52	3.87	15.51	3.94	15.49	4.01	15.47	4.07	16
17	16.50	4.11	16.48	4.18	16.46	4.26	16.44	4.33	17
18	17.47	4.35	17.45	4.43	17.43	4.51	17.41	4.58	18
19	18.44	4.60	18.42	4.68	18.39	4.76	18.37	4.84	19
20	19.41	4.84	19.38	4.92	19.36	5.01	19.34	5.09	20
21	20.38	5.08	20.35	5.17	20.33	5.26	20.31	5.35	21
22	21.35	5.32	21.32	5.42	21.30	5.51	21.28	5.60	22
23	22.32	5.56	22.29	5.66	22.27	5.76	22.24	5.86	23
24	23.29	5.81	23.26	5.91	23.24	6.01	23.21	6.11	24
25	24.26	6.05	24.23	6.15	24.20	6.26	24.18	6.37	25
26	25.23	6.29	25.20	6.40	25.17	6.51	25.14	6.62	26
27	26.20	6.53	26.17	6.65	26.14	6.76	26.11	6.87	27
28	27.17	6.77	27.14	6.89	27.11	7.01	27.08	7.13	28
29	28.14	7.02	28.11	7.14	28.08	7.26	28.04	7.38	29
30	29.11	7.26	29.08	7.38	29.04	7.51	29.01	7.64	30
31	30.08	7.50	30.05	7.63	30.01	7.76	29.98	7.89	31
32	31.05	7.74	31.02	7.88	30.98	8.01	30.95	8.15	32
33	32.02	7.98	31.98	8.12	31.95	8.26	31.91	8.40	33
34	32.99	8.23	32.95	8.37	32.92	8.51	32.88	8.66	34
35	33.96	8.47	33.92	8.62	33.89	8.76	33.85	8.91	35
36	34.93	8.71	34.89	8.86	34.85	9.01	34.81	9.17	36
37	35.90	8.95	35.86	9.11	35.82	9.26	35.78	9.42	37
38	36.87	9.19	36.83	9.35	36.79	9.51	36.75	9.67	38
39	37.84	9.44	37.80	9.60	37.76	9.76	37.71	9.93	39
40	38.81	9.68	38.77	9.85	38.73	10.02	38.68	10.18	40
41	39.78	9.92	39.74	10.09	39.69	10.27	39.65	10.44	41
42	40.75	10.16	40.71	10.34	40.66	10.52	40.62	10.69	42
43	41.72	10.40	41.68	10.58	41.63	10.77	41.58	10.95	43
44	42.69	10.64	42.65	10.83	42.60	11.02	42.55	11.20	44
45	43.66	10.89	43.62	11.08	43.57	11.27	43.52	11.46	45
46	44.63	11.13	44.58	11.32	44.53	11.52	44.48	11.71	46
47	45.60	11.37	45.55	11.57	45.50	11.77	45.45	11.97	47
48	46.57	11.61	46.52	11.82	46.47	12.02	46.42	12.22	48
49	47.54	11.85	47.49	12.06	47.44	12.27	47.39	12.48	49
50	48.51	12.10	48.46	12.31	48.41	12.52	48.35	12.73	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	76 Deg.		75¾ Deg.		75½ Deg.		75¼ Deg.		

Distance.	14 Deg.		14¼ Deg.		14½ Deg.		14¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	49.49	12.34	49.43	12.55	49.38	12.77	49.32	12.98	51
52	50.46	12.58	50.40	12.80	50.34	13.02	50.29	13.24	52
53	51.43	12.82	51.37	13.05	51.31	13.27	51.25	13.49	53
54	52.40	13.06	52.34	13.29	52.28	13.52	52.22	13.75	54
55	53.37	13.31	53.31	13.54	53.25	13.77	53.19	14.00	55
56	54.34	13.55	54.28	13.78	54.22	14.02	54.15	14.26	56
57	55.31	13.79	55.25	14.03	55.18	14.27	55.12	14.51	57
58	56.28	14.03	56.22	14.28	56.15	14.52	56.09	14.77	58
59	57.25	14.27	57.18	14.52	57.12	14.77	57.06	15.02	59
60	58.22	14.52	58.15	14.77	58.09	15.02	58.02	15.28	60
61	59.19	14.76	59.12	15.02	59.06	15.27	58.99	15.53	61
62	60.16	15.00	60.09	15.26	60.03	15.52	59.96	15.79	62
63	61.13	15.24	61.06	15.51	60.99	15.77	60.92	16.04	63
64	62.10	15.48	62.03	15.75	61.96	16.02	61.89	16.29	64
65	63.07	15.72	63.00	16.00	62.93	16.27	62.86	16.55	65
66	64.04	15.97	63.97	16.25	63.90	16.53	63.83	16.80	66
67	65.01	16.21	64.94	16.49	64.87	16.78	64.79	17.06	67
68	65.98	16.45	65.91	16.74	65.83	17.03	65.76	17.31	68
69	66.95	16.69	66.88	16.98	66.80	17.28	66.73	17.57	69
70	67.92	16.93	67.85	17.23	67.77	17.53	67.69	17.82	70
71	68.89	17.18	68.82	17.48	68.74	17.78	68.66	18.08	71
72	69.86	17.42	69.78	17.72	69.71	18.03	69.63	18.33	72
73	70.83	17.66	70.75	17.97	70.67	18.28	70.59	18.59	73
74	71.80	17.90	71.72	18.22	71.64	18.53	71.56	18.84	74
75	72.77	18.14	72.69	18.46	72.61	18.78	72.53	19.10	75
76	73.74	18.39	73.66	18.71	73.58	19.03	73.50	19.35	76
77	74.71	18.63	74.63	18.95	74.55	19.28	74.46	19.60	77
78	75.68	18.87	75.60	19.20	75.52	19.53	75.43	19.86	78
79	76.65	19.11	76.57	19.45	76.48	19.78	76.40	20.11	79
80	77.62	19.35	77.54	19.69	77.45	20.03	77.36	20.37	80
81	78.59	19.60	78.51	19.94	78.42	20.28	78.33	20.62	81
82	79.56	19.84	79.48	20.18	79.39	20.53	79.30	20.88	82
83	80.53	20.08	80.45	20.43	80.36	20.78	80.26	21.13	83
84	81.50	20.32	81.42	20.68	81.32	21.03	81.23	21.39	84
85	82.48	20.56	82.38	20.92	82.29	21.28	82.20	21.64	85
86	83.45	20.81	83.35	21.17	83.26	21.53	83.17	21.90	86
87	84.42	21.05	84.32	21.42	84.23	21.78	84.13	22.15	87
88	85.39	21.29	85.29	21.66	85.20	22.03	85.10	22.41	88
89	86.36	21.53	86.26	21.91	86.17	22.28	86.07	22.66	89
90	87.33	21.77	87.23	22.15	87.13	22.53	87.03	22.91	90
91	88.30	22.01	88.20	22.40	88.10	22.78	88.00	23.17	91
92	89.27	22.26	89.17	22.65	89.07	23.04	88.97	23.42	92
93	90.24	22.50	90.14	22.89	90.04	23.29	89.94	23.68	93
94	91.21	22.74	91.11	23.14	91.01	23.54	90.90	23.93	94
95	92.18	22.98	92.08	23.38	91.97	23.79	91.87	24.19	95
96	93.15	23.22	93.05	23.63	92.94	24.04	92.84	24.44	96
97	94.12	23.47	94.02	23.88	93.91	24.29	93.80	24.70	97
98	95.09	23.71	94.98	24.12	94.88	24.54	94.77	24.95	98
99	96.06	23.95	95.95	24.37	95.85	24.79	95.74	25.21	99
100	97.03	24.19	96.92	24.62	96.81	25.04	96.70	25.46	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	76 Deg.		75¾ Deg.		75½ Deg.		75¼ Deg.		

Distance.	15 Deg.		15¼ Deg.		15½ Deg.		15¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.97	0.26	0.96	0.26	0.96	0.27	0.96	0.27	1
2	1.93	0.52	1.93	0.53	1.93	0.53	1.92	0.54	2
3	2.90	0.78	2.89	0.79	2.89	0.80	2.89	0.81	3
4	3.86	1.04	3.86	1.05	3.85	1.07	3.85	1.09	4
5	4.83	1.29	4.82	1.32	4.82	1.34	4.81	1.36	5
6	5.80	1.55	5.79	1.58	5.78	1.60	5.77	1.63	6
7	6.76	1.81	6.75	1.84	6.75	1.87	6.74	1.90	7
8	7.73	2.07	7.72	2.10	7.71	2.14	7.70	2.17	8
9	8.69	2.33	8.68	2.37	8.67	2.41	8.66	2.44	9
10	9.66	2.59	9.65	2.63	9.64	2.67	9.62	2.71	10
11	10.63	2.85	10.61	2.89	10.60	2.94	10.59	2.99	11
12	11.59	3.11	11.58	3.16	11.56	3.21	11.55	3.26	12
13	12.56	3.36	12.54	3.42	12.53	3.47	12.51	3.53	13
14	13.52	3.62	13.51	3.68	13.49	3.74	13.47	3.80	14
15	14.49	3.88	14.47	3.95	14.45	4.01	14.44	4.07	15
16	15.45	4.14	15.44	4.21	15.42	4.28	15.40	4.34	16
17	16.42	4.40	16.40	4.47	16.38	4.54	16.36	4.61	17
18	17.39	4.66	17.37	4.73	17.35	4.81	17.32	4.89	18
19	18.35	4.92	18.33	5.00	18.31	5.08	18.29	5.16	19
20	19.32	5.18	19.30	5.26	19.27	5.34	19.25	5.43	20
21	20.28	5.44	20.26	5.52	20.24	5.61	20.21	5.70	21
22	21.25	5.69	21.23	5.79	21.20	5.88	21.17	5.97	22
23	22.22	5.95	22.19	6.05	22.16	6.15	22.14	6.24	23
24	23.18	6.21	23.15	6.31	23.13	6.41	23.10	6.51	24
25	24.15	6.47	24.12	6.58	24.09	6.68	24.06	6.79	25
26	25.11	6.73	25.08	6.84	25.05	6.95	25.02	7.06	26
27	26.08	6.99	26.05	7.10	26.02	7.22	25.99	7.33	27
28	27.05	7.25	27.01	7.36	26.98	7.48	26.95	7.60	28
29	28.01	7.51	27.98	7.63	27.95	7.75	27.91	7.87	29
30	28.98	7.76	28.94	7.89	28.91	8.02	28.87	8.14	30
31	29.94	8.02	29.91	8.15	29.87	8.28	29.84	8.41	31
32	30.91	8.28	30.87	8.42	30.84	8.55	30.80	8.69	32
33	31.88	8.54	31.84	8.68	31.80	8.82	31.76	8.96	33
34	32.84	8.80	32.80	8.94	32.76	9.09	32.72	9.23	34
35	33.81	9.06	33.77	9.21	33.73	9.35	33.69	9.50	35
36	34.77	9.32	34.73	9.47	34.69	9.62	34.65	9.77	36
37	35.74	9.58	35.70	9.73	35.65	9.89	35.61	10.04	37
38	36.71	9.84	36.66	10.00	36.62	10.16	36.57	10.31	38
39	37.67	10.09	37.63	10.26	37.58	10.42	37.54	10.59	39
40	38.64	10.35	38.59	10.52	38.55	10.69	38.50	10.86	40
41	39.60	10.61	39.56	10.78	39.51	10.96	39.46	11.13	41
42	40.57	10.87	40.52	11.05	40.47	11.22	40.42	11.40	42
43	41.53	11.13	41.49	11.31	41.44	11.49	41.39	11.67	43
44	42.50	11.39	42.45	11.57	42.40	11.76	42.35	11.94	44
45	43.47	11.65	43.42	11.84	43.36	12.03	43.31	12.21	45
46	44.43	11.91	44.38	12.10	44.33	12.29	44.27	12.49	46
47	45.40	12.16	45.35	12.36	45.29	12.56	45.24	12.76	47
48	46.36	12.42	46.31	12.63	46.25	12.83	46.20	13.03	48
49	47.33	12.68	47.27	12.89	47.22	13.09	47.16	13.30	49
50	48.30	12.94	48.24	13.15	48.18	13.36	48.12	13.57	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	75 Deg.		74¾ Deg.		74½ Deg.		74¼ Deg.		

Distance.	15 Deg.		15¼ Deg.		15½ Deg.		15¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	49.26	13.20	49.20	13.41	49.15	13.63	49.09	13.84	51
52	50.23	13.46	50.17	13.68	50.11	13.90	50.05	14.11	52
53	51.19	13.72	51.13	13.94	51.07	14.16	51.01	14.39	53
54	52.16	13.98	52.10	14.20	52.04	14.43	51.97	14.66	54
55	53.13	14.24	53.06	14.47	53.00	14.70	52.94	14.93	55
56	54.09	14.49	54.03	14.73	53.96	14.97	53.90	15.20	56
57	55.06	14.75	54.99	14.99	54.93	15.23	54.86	15.47	57
58	56.02	15.01	55.96	15.26	55.89	15.50	55.82	15.74	58
59	56.99	15.27	56.92	15.52	56.85	15.77	56.78	16.01	59
60	57.96	15.53	57.89	15.78	57.82	16.03	57.75	16.29	60
61	58.92	15.79	58.85	16.04	58.78	16.30	58.71	16.56	61
62	59.89	16.05	59.82	16.31	59.75	16.57	59.67	16.83	62
63	60.85	16.31	60.78	16.57	60.71	16.84	60.63	17.10	63
64	61.82	16.56	61.75	16.83	61.67	17.10	61.60	17.37	64
65	62.79	16.82	62.71	17.10	62.64	17.37	62.56	17.64	65
66	63.75	17.08	63.68	17.36	63.60	17.64	63.52	17.92	66
67	64.72	17.34	64.64	17.62	64.56	17.90	64.48	18.19	67
68	65.68	17.60	65.61	17.89	65.53	18.17	65.45	18.46	68
69	66.65	17.86	66.57	18.15	66.49	18.44	66.41	18.73	69
70	67.61	18.12	67.54	18.41	67.45	18.71	67.37	19.00	70
71	68.58	18.38	68.50	18.68	68.42	18.97	68.33	19.27	71
72	69.55	18.63	69.46	18.94	69.38	19.24	69.30	19.54	72
73	70.51	18.89	70.43	19.20	70.35	19.51	70.26	19.82	73
74	71.48	19.15	71.39	19.46	71.31	19.78	71.22	20.09	74
75	72.44	19.41	72.36	19.73	72.27	20.04	72.18	20.36	75
76	73.41	19.67	73.32	19.99	73.24	20.31	73.15	20.63	76
77	74.38	19.93	74.29	20.25	74.20	20.58	74.11	20.90	77
78	75.34	20.19	75.25	20.52	75.16	20.84	75.07	21.17	78
79	76.31	20.45	76.22	20.78	76.13	21.11	76.03	21.44	79
80	77.27	20.71	77.18	21.04	77.09	21.38	77.00	21.72	80
81	78.24	20.96	78.15	21.31	78.05	21.65	77.96	21.99	81
82	79.21	21.22	79.11	21.57	79.02	21.91	78.92	22.26	82
83	80.17	21.48	80.08	21.83	79.98	22.18	79.88	22.53	83
84	81.14	21.74	81.04	22.09	80.94	22.45	80.85	22.80	84
85	82.10	22.00	82.01	22.36	81.91	22.72	81.81	23.07	85
86	83.07	22.26	82.97	22.62	82.87	22.98	82.77	23.34	86
87	84.04	22.52	83.94	22.88	83.84	23.25	83.73	23.62	87
88	85.00	22.78	84.90	23.15	84.80	23.52	84.70	23.89	88
89	85.97	23.03	85.87	23.41	85.76	23.78	85.66	24.16	89
90	86.93	23.29	86.83	23.67	86.73	24.05	86.62	24.43	90
91	87.90	23.55	87.80	23.94	87.69	24.32	87.58	24.70	91
92	88.87	23.81	88.76	24.20	88.65	24.59	88.55	24.97	92
93	89.83	24.07	89.73	24.46	89.62	24.85	89.51	25.24	93
94	90.80	24.33	90.69	24.72	90.58	25.12	90.47	25.52	94
95	91.76	24.59	91.65	24.99	91.54	25.39	91.43	25.79	95
96	92.73	24.85	92.62	25.25	92.51	25.65	92.40	26.06	96
97	93.69	25.11	93.58	25.51	93.47	25.92	93.36	26.33	97
98	94.66	25.36	94.55	25.78	94.44	26.19	94.32	26.60	98
99	95.63	25.62	95.51	26.04	95.40	26.46	95.28	26.87	99
100	96.59	25.88	96.48	26.30	96.36	26.72	96.25	27.14	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	75 Deg.		74¾ Deg.		74½ Deg.		74¼ Deg.		

Distance.	16 Deg.		16¼ Deg.		16½ Deg.		16¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.96	0.28	0.96	0.28	0.96	0.28	0.96	0.29	1
2	1.92	0.55	1.92	0.56	1.92	0.57	1.92	0.58	2
3	2.88	0.83	2.88	0.84	2.88	0.85	2.87	0.86	3
4	3.85	1.10	3.84	1.12	3.84	1.14	3.83	1.15	4
5	4.81	1.38	4.80	1.40	4.79	1.42	4.79	1.44	5
6	5.77	1.65	5.76	1.68	5.75	1.70	5.75	1.73	6
7	6.73	1.93	6.72	1.96	6.71	1.99	6.70	2.02	7
8	7.69	2.21	7.68	2.24	7.67	2.27	7.66	2.31	8
9	8.65	2.48	8.64	2.52	8.63	2.56	8.62	2.59	9
10	9.61	2.76	9.60	2.80	9.59	2.84	9.58	2.88	10
11	10.57	3.03	10.56	3.08	10.55	3.12	10.53	3.17	11
12	11.54	3.31	11.52	3.36	11.51	3.41	11.49	3.46	12
13	12.50	3.58	12.48	3.64	12.46	3.69	12.45	3.75	13
14	13.46	3.86	13.44	3.92	13.42	3.98	13.41	4.03	14
15	14.42	4.13	14.40	4.20	14.38	4.26	14.36	4.32	15
16	15.38	4.41	15.36	4.48	15.34	4.54	15.32	4.61	16
17	16.34	4.69	16.32	4.76	16.30	4.83	16.28	4.90	17
18	17.30	4.96	17.28	5.04	17.26	5.11	17.24	5.19	18
19	18.26	5.24	18.24	5.32	18.22	5.40	18.19	5.48	19
20	19.23	5.51	19.20	5.60	19.18	5.68	19.15	5.76	20
21	20.19	5.79	20.16	5.88	20.14	5.96	20.11	6.05	21
22	21.15	6.06	21.12	6.16	21.09	6.25	21.07	6.34	22
23	22.11	6.34	22.08	6.44	22.05	6.53	22.02	6.63	23
24	23.07	6.62	23.04	6.72	23.01	6.82	22.98	6.92	24
25	24.03	6.89	24.00	7.00	23.97	7.10	23.94	7.20	25
26	24.99	7.17	24.96	7.28	24.93	7.38	24.90	7.49	26
27	25.95	7.44	25.92	7.56	25.89	7.67	25.85	7.78	27
28	26.92	7.72	26.88	7.84	26.85	7.95	26.81	8.07	28
29	27.88	7.99	27.84	8.11	27.81	8.24	27.77	8.36	29
30	28.84	8.27	28.80	8.39	28.76	8.52	28.73	8.65	30
31	29.80	8.54	29.76	8.67	29.72	8.80	29.68	8.93	31
32	30.76	8.82	30.72	8.95	30.68	9.09	30.64	9.22	32
33	31.72	9.10	31.68	9.23	31.64	9.37	31.60	9.51	33
34	32.68	9.37	32.64	9.51	32.60	9.66	32.56	9.80	34
35	33.64	9.65	33.60	9.79	33.56	9.94	33.51	10.09	35
36	34.61	9.92	34.56	10.07	34.52	10.22	34.47	10.38	36
37	35.57	10.20	35.52	10.35	35.48	10.51	35.43	10.66	37
38	36.53	10.47	36.48	10.63	36.44	10.79	36.39	10.95	38
39	37.49	10.75	37.44	10.91	37.39	11.08	37.35	11.24	39
40	38.45	11.03	38.40	11.19	38.35	11.36	38.30	11.53	40
41	39.41	11.30	39.36	11.47	39.31	11.64	39.26	11.82	41
42	40.37	11.58	40.32	11.75	40.27	11.93	40.22	12.10	42
43	41.33	11.85	41.28	12.03	41.23	12.21	41.18	12.39	43
44	42.30	12.13	42.24	12.31	42.19	12.50	42.13	12.68	44
45	43.26	12.40	43.20	12.59	43.15	12.78	43.09	12.97	45
46	44.22	12.68	44.16	12.87	44.11	13.06	44.05	13.26	46
47	45.18	12.95	45.12	13.15	45.06	13.35	45.01	13.55	47
48	46.14	13.23	46.08	13.43	46.02	13.63	45.96	13.83	48
49	47.10	13.51	47.04	13.71	46.98	13.92	46.92	14.12	49
50	48.06	13.78	48.00	13.99	47.94	14.20	47.88	14.41	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	74 Deg.		73¾ Deg.		73½ Deg.		73¼ Deg.		

Distance.	16 Deg.		16¼ Deg.		16½ Deg.		16¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	49.02	14.06	48.96	14.27	48.90	14.48	48.84	14.70	51
52	49.99	14.33	49.92	14.55	49.86	14.77	49.79	14.99	52
53	50.95	14.61	50.88	14.83	50.82	15.05	50.75	15.27	53
54	51.91	14.88	51.84	15.11	51.78	15.34	51.71	15.56	54
55	52.87	15.16	52.80	15.39	52.74	15.62	52.67	15.85	55
56	53.83	15.44	53.76	15.67	53.69	15.90	53.62	16.14	56
57	54.79	15.71	54.72	15.95	54.65	16.19	54.58	16.43	57
58	55.75	15.99	55.68	16.23	55.61	16.47	55.54	16.72	58
59	56.71	16.26	56.64	16.51	56.57	16.76	56.50	17.00	59
60	57.68	16.54	57.60	16.79	57.53	17.04	57.45	17.29	60
61	58.64	16.81	58.56	17.07	58.49	17.32	58.41	17.58	61
62	59.60	17.09	59.52	17.35	59.45	17.61	59.37	17.87	62
63	60.56	17.37	60.48	17.63	60.41	17.89	60.33	18.16	63
64	61.52	17.64	61.44	17.91	61.36	18.18	61.28	18.44	64
65	62.48	17.92	62.40	18.19	62.32	18.46	62.24	18.73	65
66	63.44	18.19	63.36	18.47	63.28	18.74	63.20	19.02	66
67	64.40	18.47	64.32	18.75	64.24	19.03	64.16	19.31	67
68	65.37	18.74	65.28	19.03	65.20	19.31	65.11	19.60	68
69	66.33	19.02	66.24	19.31	66.16	19.60	66.07	19.89	69
70	67.29	19.29	67.20	19.59	67.12	19.88	67.03	20.17	70
71	68.25	19.57	68.16	19.87	68.08	20.17	67.99	20.46	71
72	69.21	19.85	69.12	20.15	69.03	20.45	68.95	20.75	72
73	70.17	20.12	70.08	20.43	69.99	20.73	69.90	21.04	73
74	71.13	20.40	71.04	20.71	70.95	21.02	70.86	21.33	74
75	72.09	20.67	72.00	20.99	71.91	21.30	71.82	21.61	75
76	73.06	20.95	72.96	21.27	72.87	21.59	72.78	21.90	76
77	74.02	21.22	73.92	21.55	73.83	21.87	73.73	22.19	77
78	74.98	21.50	74.88	21.83	74.79	22.15	74.69	22.48	78
79	75.94	21.78	75.84	22.11	75.75	22.44	75.65	22.77	79
80	76.90	22.05	76.80	22.39	76.71	22.72	76.61	23.06	80
81	77.86	22.33	77.76	22.67	77.66	23.01	77.56	23.34	81
82	78.82	22.60	78.72	22.95	78.62	23.29	78.52	23.63	82
83	79.78	22.88	79.68	23.23	79.58	23.57	79.48	23.92	83
84	30.75	23.15	80.64	23.51	80.54	23.86	80.44	24.21	84
85	81.71	23.43	81.60	23.79	81.50	24.14	81.39	24.50	85
86	82.67	23.70	82.56	24.07	82.46	24.43	82.35	24.78	86
87	83.63	23.98	83.52	24.35	83.42	24.71	83.31	25.07	87
88	84.59	24.26	84.48	24.62	84.38	24.99	84.27	25.36	88
89	85.55	24.53	85.44	24.90	85.33	25.28	85.22	25.65	89
90	86.51	24.81	86.40	25.18	86.29	25.56	86.18	25.94	90
91	87.47	25.08	87.36	25.46	87.25	25.85	87.14	26.23	91
92	88.44	25.36	88.32	25.74	88.21	26.13	88.10	26.51	92
93	89.40	25.63	89.28	26.02	89.17	26.41	89.05	26.80	93
94	90.36	25.91	90.24	26.30	90.13	26.70	90.01	27.09	94
95	91.32	26.19	91.20	26.58	91.09	26.98	90.97	27.38	95
96	92.28	26.46	92.16	26.86	92.05	27.27	91.93	27.67	96
97	93.24	26.74	93.12	27.14	93.01	27.55	92.88	27.95	97
98	94.20	27.01	94.08	27.42	93.96	27.83	93.84	28.24	98
99	95.16	27.29	95.04	27.70	94.92	28.12	94.80	28.53	99
100	96.13	27.56	96.00	27.98	95.88	28.40	95.76	28.82	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	74 Deg.		73¾ Deg.		73½ Deg.		73¼ Deg.		

Distance.	17 Deg.		17¼ Deg.		17½ Deg.		17¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.96	0.29	0.95	0.30	0.95	0.30	0.95	0.30	1
2	1.91	0.58	1.91	0.59	1.91	0.60	1.90	0.61	2
3	2.87	0.88	2.87	0.89	2.86	0.90	2.86	0.91	3
4	3.83	1.17	3.82	1.19	3.81	1.20	3.81	1.22	4
5	4.78	1.46	4.78	1.48	4.77	1.50	4.76	1.52	5
6	5.74	1.75	5.73	1.78	5.72	1.80	5.71	1.83	6
7	6.69	2.05	6.69	2.08	6.68	2.10	6.67	2.13	7
8	7.65	2.34	7.64	2.37	7.63	2.41	7.62	2.44	8
9	8.61	2.63	8.60	2.67	8.58	2.71	8.57	2.74	9
10	9.56	2.92	9.55	2.97	9.54	3.01	9.52	3.05	10
11	10.52	3.22	10.51	3.26	10.49	3.31	10.48	3.35	11
12	11.48	3.51	11.46	3.56	11.44	3.61	11.43	3.66	12
13	12.43	3.80	12.42	3.85	12.40	3.91	12.38	3.96	13
14	13.39	4.09	13.37	4.15	13.35	4.21	13.33	4.27	14
15	14.34	4.39	14.33	4.45	14.31	4.51	14.29	4.57	15
16	15.30	4.68	15.28	4.74	15.26	4.81	15.24	4.88	16
17	16.26	4.97	16.24	5.04	16.21	5.11	16.19	5.18	17
18	17.21	5.26	17.19	5.34	17.17	5.41	17.14	5.49	18
19	18.17	5.56	18.15	5.63	18.12	5.71	18.10	5.79	19
20	19.13	5.85	19.10	5.93	19.07	6.01	19.05	6.10	20
21	20.08	6.14	20.06	6.23	20.03	6.31	20.00	6.40	21
22	21.04	6.43	21.01	6.52	20.98	6.62	20.95	6.71	22
23	21.99	6.72	21.97	6.82	21.94	6.92	21.91	7.01	23
24	22.95	7.02	22.92	7.12	22.89	7.22	22.86	7.32	24
25	23.91	7.31	23.88	7.41	23.84	7.52	23.81	7.62	25
26	24.86	7.60	24.83	7.71	24.80	7.82	24.76	7.93	26
27	25.82	7.89	25.79	8.01	25.75	8.12	25.71	8.23	27
28	26.78	8.19	26.74	8.30	26.70	8.42	26.67	8.54	28
29	27.73	8.48	27.70	8.60	27.66	8.72	27.62	8.84	29
30	28.69	8.77	28.65	8.90	28.61	9.02	28.57	9.15	30
31	29.65	9.06	29.61	9.19	29.57	9.32	29.52	9.45	31
32	30.60	9.36	30.56	9.49	30.52	9.62	30.48	9.76	32
33	31.56	9.65	31.52	9.79	31.47	9.92	31.43	10.06	33
34	32.51	9.94	32.47	10.08	32.43	10.22	32.38	10.37	34
35	33.47	10.23	33.43	10.38	33.38	10.52	33.33	10.67	35
36	34.43	10.53	34.38	10.68	34.33	10.83	34.29	10.98	36
37	35.38	10.82	35.34	10.97	35.29	11.13	35.24	11.28	37
38	36.34	11.11	36.29	11.27	36.24	11.43	36.19	11.58	38
39	37.30	11.40	37.25	11.57	37.19	11.73	37.14	11.89	39
40	38.25	11.69	38.20	11.86	38.15	12.03	38.10	12.19	40
41	39.21	11.99	39.16	12.16	39.10	12.33	39.05	12.50	41
42	40.16	12.28	40.11	12.45	40.06	12.63	40.00	12.80	42
43	41.12	12.57	41.07	12.75	41.01	12.93	40.95	13.11	43
44	42.08	12.86	42.02	13.05	41.96	13.23	41.91	13.41	44
45	43.03	13.16	42.98	13.34	42.92	13.53	42.86	13.72	45
46	43.99	13.45	43.93	13.64	43.87	13.83	43.81	14.02	46
47	44.95	13.74	44.89	13.94	44.82	14.13	44.76	14.33	47
48	45.90	14.03	45.84	14.23	45.78	14.43	45.71	14.63	48
49	46.86	14.33	46.80	14.53	46.73	14.73	46.67	14.94	49
50	47.82	14.62	47.75	14.83	47.69	15.04	47.62	15.24	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	73 Deg.		72¾ Deg.		72½ Deg.		72¼ Deg.		

Distance.	17 Deg.		17¼ Deg.		17½ Deg.		17¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	48.77	14.91	48.71	15.12	48.64	15.34	48.57	15.55	51
52	49.73	15.20	49.66	15.42	49.59	15.64	49.52	15.85	52
53	50.68	15.50	50.62	15.72	50.55	15.94	50.48	16.16	53
54	51.64	15.79	51.57	16.01	51.50	16.24	51.43	16.46	54
55	52.60	16.08	52.53	16.31	52.45	16.54	52.38	16.77	55
56	53.55	16.37	53.48	16.61	53.41	16.84	53.33	17.07	56
57	54.51	16.67	54.44	16.90	54.36	17.14	54.29	17.38	57
58	55.47	16.96	55.39	17.20	55.32	17.44	55.24	17.68	58
59	56.42	17.25	56.35	17.50	56.27	17.74	56.19	17.99	59
60	57.38	17.54	57.30	17.79	57.22	18.04	57.14	18.29	60
61	58.33	17.83	58.26	18.09	58.18	18.34	58.10	18.60	61
62	59.29	18.13	59.21	18.39	59.13	18.64	59.05	18.90	62
63	60.25	18.42	60.17	18.68	60.08	18.94	60.00	19.21	63
64	61.20	18.71	61.12	18.98	61.04	19.25	60.95	19.51	64
65	62.16	19.00	62.08	19.28	61.99	19.55	61.91	19.82	65
66	63.12	19.30	63.03	19.57	62.95	19.85	62.86	20.12	66
67	64.07	19.59	63.99	19.87	63.90	20.15	63.81	20.43	67
68	65.03	19.88	64.94	20.16	64.85	20.45	64.76	20.73	68
69	65.99	20.17	65.90	20.46	65.81	20.75	65.72	21.04	69
70	66.94	20.47	66.85	20.76	66.76	21.05	66.67	21.34	70
71	67.90	20.76	67.81	21.05	67.71	21.35	67.62	21.65	71
72	68.85	21.05	68.76	21.35	68.67	21.65	68.57	21.95	72
73	69.81	21.34	69.72	21.65	69.62	21.95	69.52	22.26	73
74	70.77	21.64	70.67	21.94	70.58	22.25	70.48	22.56	74
75	71.72	21.93	71.63	22.24	71.53	22.55	71.43	22.86	75
76	72.68	22.22	72.58	22.54	72.48	22.85	72.38	23.17	76
77	73.64	22.51	73.54	22.83	73.44	23.15	73.33	23.47	77
78	74.59	22.80	74.49	23.13	74.39	23.46	74.29	23.78	78
79	75.55	23.10	75.45	23.43	75.34	23.76	75.24	24.08	79
80	76.50	23.39	76.40	23.72	76.30	24.06	76.19	24.39	80
81	77.46	23.68	77.36	24.02	77.25	24.36	77.14	24.69	81
82	78.42	23.97	78.31	24.32	78.20	24.66	78.10	25.00	82
83	79.37	24.27	79.27	24.61	79.16	25.96	79.05	25.30	83
84	80.33	24.56	80.22	24.91	80.11	25.26	80.00	25.61	84
85	81.29	24.85	81.18	25.21	81.07	25.56	80.95	25.91	85
86	82.24	25.14	82.13	25.50	82.02	25.86	81.91	26.22	86
87	83.20	25.44	83.09	25.80	82.97	26.16	82.86	26.52	87
88	84.15	25.73	84.04	26.10	83.93	26.46	83.81	26.83	88
89	85.11	26.02	85.00	26.39	84.88	26.76	84.76	27.13	89
90	86.07	26.31	85.95	26.69	85.83	27.06	85.72	27.44	90
91	87.02	26.61	86.91	26.99	86.79	27.36	86.67	27.74	91
92	87.98	26.90	87.86	27.28	87.74	27.66	87.62	28.05	92
93	88.94	27.19	88.82	27.58	88.70	27.97	88.57	28.35	93
94	89.89	27.48	89.77	27.87	89.65	28.27	89.53	28.66	94
95	90.85	27.78	90.73	28.17	90.60	28.57	90.48	28.96	95
96	91.81	28.07	91.68	28.47	91.56	28.87	91.43	29.27	96
97	92.76	28.36	92.64	28.76	92.51	29.17	92.38	29.57	97
98	93.72	28.65	93.59	29.06	93.46	29.47	93.33	29.88	98
99	94.67	28.94	94.55	29.36	94.42	29.77	94.29	30.18	99
100	95.63	29.24	95.50	29.65	95.37	30.07	95.24	30.49	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	73 Deg.		72¾ Deg.		72½ Deg.		72¼ Deg.		

Distance.	18 Deg.		18¼ Deg.		18½ Deg.		18¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.95	0.31	0.95	0.31	0.95	0.32	0.95	0.32	1
2	1.90	0.62	1.90	0.63	1.90	0.63	1.89	0.64	2
3	2.85	0.93	2.85	0.94	2.84	0.95	2.84	0.96	3
4	3.80	1.24	3.80	1.25	3.79	1.27	3.79	1.29	4
5	4.76	1.55	4.75	1.57	4.74	1.59	4.73	1.61	5
6	5.71	1.85	5.70	1.88	5.69	1.90	5.68	1.93	6
7	6.66	2.16	6.65	2.19	6.64	2.22	6.63	2.25	7
8	7.61	2.47	7.60	2.51	7.59	2.54	7.58	2.57	8
9	8.56	2.78	8.55	2.82	8.53	2.86	8.52	2.89	9
10	9.51	3.09	9.50	3.13	9.48	3.17	9.47	3.21	10
11	10.46	3.40	10.45	3.44	10.43	3.49	10.42	3.54	11
12	11.41	3.71	11.40	3.76	11.38	3.81	11.36	3.86	12
13	12.36	4.02	12.35	4.07	12.33	4.12	12.31	4.18	13
14	13.31	4.33	13.30	4.38	13.28	4.44	13.26	4.50	14
15	14.27	4.64	14.25	4.70	14.22	4.76	14.20	4.82	15
16	15.22	4.94	15.20	5.01	15.17	5.08	15.15	5.14	16
17	16.17	5.25	16.14	5.32	16.12	5.39	16.10	5.46	17
18	17.12	5.56	17.09	5.64	17.07	5.71	17.04	5.79	18
19	18.07	5.87	18.04	5.95	18.02	6.03	17.99	6.11	19
20	19.02	6.18	18.99	6.26	18.97	6.35	18.94	6.43	20
21	19.97	6.49	19.94	6.58	19.91	6.66	19.89	6.75	21
22	20.92	6.80	20.89	6.89	20.86	6.98	20.83	7.07	22
23	21.87	7.11	21.84	7.20	21.81	7.30	21.78	7.39	23
24	22.83	7.42	22.79	7.52	22.76	7.62	22.73	7.71	24
25	23.78	7.73	23.74	7.83	23.71	7.93	23.67	8.04	25
26	24.73	8.03	24.69	8.14	24.66	8.25	24.62	8.36	26
27	25.68	8.34	25.64	8.46	25.60	8.57	25.57	8.68	27
28	26.63	8.65	26.59	8.77	26.55	8.88	26.51	9.00	28
29	27.58	8.96	27.54	9.08	27.50	9.20	27.46	9.32	29
30	28.53	9.27	28.49	9.39	28.45	9.52	28.41	9.64	30
31	29.48	9.58	29.44	9.71	29.40	9.84	29.35	9.96	31
32	30.43	9.89	30.39	10.02	30.35	10.15	30.30	10.29	32
33	31.38	10.20	31.34	10.33	31.29	10.47	31.25	10.61	33
34	32.34	10.51	32.29	10.65	32.24	10.79	32.20	10.93	34
35	33.29	10.82	33.24	10.96	33.19	11.11	33.14	11.25	35
36	34.24	11.12	34.19	11.27	34.14	11.42	34.09	11.57	36
37	35.19	11.43	35.14	11.59	35.09	11.74	35.04	11.89	37
38	36.14	11.74	36.09	11.90	36.04	12.06	35.98	12.21	38
39	37.09	12.05	37.04	12.21	36.98	12.37	36.93	12.54	39
40	38.04	12.36	37.99	12.53	37.93	12.69	37.88	12.86	40
41	38.99	12.67	38.94	12.84	38.88	13.01	38.82	13.18	41
42	39.94	12.98	39.89	13.15	39.83	13.33	39.77	13.50	42
43	40.90	13.29	40.84	13.47	40.78	13.64	40.72	13.82	43
44	41.85	13.60	41.79	13.78	41.73	13.96	41.66	14.14	44
45	42.80	13.91	42.74	14.09	42.67	14.28	42.61	14.46	45
46	43.75	14.21	43.69	14.41	43.62	14.60	43.56	14.79	46
47	44.70	14.52	44.64	14.72	44.57	14.91	44.51	15.11	47
48	45.65	14.83	45.59	15.03	45.52	15.23	45.45	15.43	48
49	46.60	15.14	46.54	15.35	46.47	15.55	46.40	15.75	49
50	47.55	15.45	47.48	15.66	47.42	15.87	47.35	16.07	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	72 Deg.		71¾ Deg.		71½ Deg.		71¼ Deg.		

Distance.	18 Deg.		18¼ Deg.		18½ Deg.		18¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	48.50	15.76	48.43	15.97	48.36	16.18	48.29	16.39	51
52	49.45	16.07	49.38	16.28	49.31	16.50	49.24	16.71	52
53	50.41	16.38	50.33	16.60	50.26	16.82	50.19	17.04	53
54	51.36	16.69	51.28	16.91	51.21	17.13	51.13	17.36	54
55	52.31	17.00	52.23	17.22	52.16	17.45	52.08	17.68	55
56	53.26	17.30	53.18	17.54	53.11	17.77	53.03	18.00	56
57	54.21	17.61	54.13	17.85	54.05	18.09	53.98	18.32	57
58	55.16	17.92	55.08	18.16	55.00	18.40	54.92	18.64	58
59	56.11	18.23	56.03	18.48	55.95	18.72	55.87	18.96	59
60	57.06	18.54	56.98	18.79	56.90	19.04	56.82	19.29	60
61	58.01	18.85	57.93	19.10	57.85	19.36	57.76	19.61	61
62	58.97	19.16	58.88	19.42	58.80	19.67	58.71	19.93	62
63	59.92	19.47	59.83	19.73	59.74	19.99	59.66	20.25	63
64	60.87	19.78	60.78	20.04	60.69	20.31	60.60	20.57	64
65	61.82	20.09	61.73	20.36	61.64	20.62	61.55	20.89	65
66	62.77	20.40	62.68	20.67	62.59	20.94	62.50	21.22	66
67	63.72	20.70	63.63	20.98	63.54	21.26	63.44	21.54	67
68	64.67	21.01	64.58	21.30	64.49	21.58	64.39	21.86	68
69	65.62	21.32	65.53	21.61	65.43	21.89	65.34	22.18	69
70	66.57	21.63	66.48	21.92	66.38	22.21	66.29	22.50	70
71	67.53	21.94	67.43	22.23	67.33	22.53	67.23	22.82	71
72	68.48	22.25	68.38	22.55	68.28	22.85	68.18	23.14	72
73	69.43	22.56	69.33	22.86	69.23	23.16	69.13	23.47	73
74	70.38	22.87	70.28	23.17	70.18	23.48	70.07	23.79	74
75	71.33	23.18	71.23	23.49	71.12	23.80	71.02	24.11	75
76	72.28	23.49	72.18	23.80	72.07	24.12	71.97	24.43	76
77	73.23	23.79	73.13	24.11	73.02	24.43	72.91	24.75	77
78	74.18	24.10	74.08	24.43	73.97	24.75	73.86	25.07	78
79	75.13	24.41	75.03	24.74	74.92	25.07	74.81	25.39	79
80	76.08	24.72	75.98	25.05	75.87	25.38	75.75	25.72	80
81	77.04	25.03	76.93	25.37	76.81	25.70	76.70	26.04	81
82	77.99	25.34	77.88	25.68	77.76	26.02	77.65	26.36	82
83	78.94	25.65	78.83	25.99	78.71	26.34	78.60	26.68	83
84	79.89	25.96	79.77	26.31	79.66	26.65	79.54	27.00	84
85	80.84	26.27	80.72	26.62	80.61	26.97	80.49	27.32	85
86	81.79	26.58	81.67	26.93	81.56	27.29	81.44	27.64	86
87	82.74	26.88	82.62	27.25	82.50	27.61	82.38	27.97	87
88	83.69	27.19	83.57	27.56	83.45	27.92	83.33	28.29	88
89	84.04	27.50	84.52	27.87	84.40	28.24	84.28	28.61	89
90	85.60	27.81	85.47	28.18	85.35	28.56	85.22	28.93	90
91	86.55	28.12	86.42	28.50	86.30	28.87	86.17	29.25	91
92	87.50	28.43	87.37	28.81	87.25	29.19	87.12	29.57	92
93	88.45	28.74	88.32	29.12	88.19	29.51	88.06	29.89	93
94	89.40	29.05	89.27	29.44	89.14	29.83	89.01	30.22	94
95	90.35	29.36	90.22	29.75	90.09	30.14	89.96	30.54	95
96	91.30	29.67	91.17	30.06	91.04	30.46	90.91	30.86	96
97	92.25	29.97	92.12	30.38	91.99	30.78	91.85	31.18	97
98	93.20	30.28	93.07	30.69	92.94	31.10	92.80	31.50	98
99	94.15	30.59	94.02	31.00	93.88	31.41	93.75	31.82	99
100	95.11	30.90	94.97	31.32	94.83	31.73	94.69	32.14	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	72 Deg.		71¾ Deg.		71½ Deg.		71¼ Deg.		

Distance.	19 Deg.		19¼ Deg.		19½ Deg.		19¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.95	0.33	0.94	0.33	0.94	0.33	0.94	0.34	1
2	1.89	0.65	1.89	0.66	1.89	0.67	1.88	0.68	2
3	2.84	0.98	2.83	0.99	2.83	1.00	2.82	1.01	3
4	3.78	1.30	3.78	1.32	3.77	1.34	3.76	1.35	4
5	4.73	1.63	4.72	1.65	4.71	1.67	4.71	1.69	5
6	5.67	1.95	5.66	1.98	5.66	2.00	5.65	2.03	6
7	6.62	2.28	6.61	2.31	6.60	2.34	6.59	2.37	7
8	7.56	2.60	7.55	2.64	7.54	2.67	7.53	2.70	8
9	8.51	2.93	8.50	2.97	8.48	3.00	8.47	3.04	9
10	9.46	3.26	9.44	3.30	9.43	3.34	9.41	3.38	10
11	10.40	3.58	10.38	3.63	10.37	3.67	10.35	3.72	11
12	11.35	3.91	11.33	3.96	11.31	4.01	11.29	4.06	12
13	12.29	4.23	12.27	4.29	12.25	4.34	12.24	4.39	13
14	13.24	4.56	13.22	4.62	13.20	4.67	13.18	4.73	14
15	14.18	4.88	14.16	4.95	14.14	5.01	14.12	5.07	15
16	15.13	5.21	15.11	5.28	15.08	5.34	15.06	5.41	16
17	16.07	5.53	16.05	5.60	16.02	5.67	16.00	5.74	17
18	17.02	5.86	16.99	5.93	16.97	6.01	16.94	6.08	18
19	17.96	6.19	17.94	6.26	17.91	6.34	17.88	6.42	19
20	18.91	6.51	18.88	6.59	18.85	6.68	18.82	6.76	20
21	19.86	6.84	19.83	6.92	19.80	7.01	19.76	7.10	21
22	20.80	7.16	20.77	7.25	20.74	7.34	20.71	7.43	22
23	21.75	7.49	21.71	7.58	21.68	7.68	21.65	7.77	23
24	22.69	7.81	22.66	7.91	22.62	8.01	22.59	8.11	24
25	23.64	8.14	23.60	8.24	23.57	8.35	23.53	8.45	25
26	24.58	8.46	24.55	8.57	24.51	8.68	24.47	8.79	26
27	25.53	8.79	25.49	8.90	25.45	9.01	25.41	9.12	27
28	26.47	9.12	26.43	9.23	26.39	9.35	26.35	9.46	28
29	27.42	9.44	27.38	9.56	27.34	9.68	27.29	9.80	29
30	28.37	9.77	28.32	9.89	28.28	10.01	28.24	10.14	30
31	29.31	10.09	29.27	10.22	29.22	10.35	29.18	10.48	31
32	30.26	10.42	30.21	10.55	30.16	10.68	30.12	10.81	32
33	31.20	10.74	31.15	10.88	31.11	11.02	31.06	11.15	33
34	32.15	11.07	32.10	11.21	32.05	11.35	32.00	11.49	34
35	33.09	11.39	33.04	11.54	32.99	11.68	32.94	11.83	35
36	34.04	11.72	33.99	11.87	33.94	12.02	33.88	12.17	36
37	34.98	12.05	34.93	12.20	34.88	12.35	34.82	12.50	37
38	35.93	12.37	35.88	12.53	35.82	12.68	35.76	12.84	38
39	36.88	12.70	36.82	12.86	36.76	13.02	36.71	13.18	39
40	37.82	13.02	37.76	13.19	37.71	13.35	37.65	13.52	40
41	38.77	13.35	38.71	13.52	38.65	13.69	38.59	13.85	41
42	39.71	13.67	39.65	13.85	39.59	14.02	39.53	14.19	42
43	40.66	14.00	40.60	14.18	40.53	14.35	40.47	14.53	43
44	41.60	14.32	41.54	14.51	41.48	14.69	41.41	14.87	44
45	42.55	14.65	42.48	14.84	42.42	15.02	42.35	15.21	45
46	43.49	14.98	43.43	15.17	43.36	15.36	43.29	15.54	46
47	44.44	15.30	44.37	15.50	44.30	15.69	44.24	15.88	47
48	45.38	15.63	45.32	15.83	45.25	16.02	45.18	16.22	48
49	46.33	15.95	46.26	16.15	46.19	16.36	46.12	16.56	49
50	47.28	16.28	47.20	16.48	47.13	16.69	47.06	16.90	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	71 Deg.		70¾ Deg.		70½ Deg.		70¼ Deg.		

Distance.	19 Deg.		19¼ Deg.		19½ Deg.		19¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	48.22	16.60	48.15	16.81	48.07	17.02	48.00	17.23	51
52	49.17	16.93	49.09	17.14	49.02	17.36	48.94	17.57	52
53	50.11	17.26	50.04	17.47	49.96	17.69	49.88	17.91	53
54	51.06	17.58	50.98	17.80	50.90	18.03	50.82	18.25	54
55	52.00	17.91	51.92	18.13	51.85	18.36	51.76	18.59	55
56	52.95	18.23	52.87	18.46	52.79	18.69	52.71	18.92	56
57	53.89	18.56	53.81	18.79	53.73	19.03	53.65	19.26	57
58	54.84	18.88	54.76	19.12	54.67	19.36	54.59	19.60	58
59	55.79	19.21	55.70	19.45	55.62	19.69	55.53	19.94	59
60	56.73	19.53	56.65	19.78	56.56	20.03	56.47	20.27	60
61	57.68	19.86	57.59	20.11	57.50	20.36	57.41	20.61	61
62	58.62	20.19	58.53	20.44	58.44	20.70	58.35	20.95	62
63	59.57	20.51	59.48	20.77	59.39	21.03	59.29	21.29	63
64	60.51	20.84	60.42	21.10	60.33	21.36	60.24	21.63	64
65	61.46	21.16	61.37	21.43	61.27	21.70	61.18	21.96	65
66	62.40	21.49	62.31	21.76	62.21	22.03	62.12	22.30	66
67	63.35	21.81	63.25	22.09	63.16	22.37	63.06	22.64	67
68	64.30	22.14	64.20	22.42	64.10	22.70	64.00	22.98	68
69	65.24	22.46	65.14	22.75	65.04	23.03	64.94	23.32	69
70	66.19	22.79	66.09	23.08	65.98	23.37	65.88	23.65	70
71	67.13	23.12	67.03	23.41	66.93	23.70	66.82	23.99	71
72	68.08	23.44	67.97	23.74	67.87	24.03	67.76	24.33	72
73	69.02	23.77	68.92	24.07	68.81	24.37	68.71	24.67	73
74	69.97	24.09	69.86	24.40	69.76	24.70	69.65	25.01	74
75	70.91	24.42	70.81	24.73	70.70	25.04	70.59	25.34	75
76	71.86	24.74	71.75	25.06	71.64	25.37	71.53	25.68	76
77	72.80	25.07	72.69	25.39	72.58	25.70	72.47	26.02	77
78	73.75	25.39	73.64	25.72	73.53	26.04	73.41	26.36	78
79	74.70	25.72	74.58	26.05	74.47	26.37	74.35	26.70	79
80	75.64	26.05	75.53	26.38	75.41	26.70	75.29	27.03	80
81	76.59	26.37	76.47	26.70	76.35	27.04	76.24	27.37	81
82	77.53	26.70	77.42	27.03	77.30	27.37	77.18	27.71	82
83	78.48	27.02	78.36	27.36	78.24	27.71	78.12	28.05	83
84	79.42	27.35	79.30	27.69	79.18	28.04	79.06	28.39	84
85	80.37	27.67	80.25	28.02	80.12	28.37	80.00	28.72	85
86	81.31	28.00	81.19	28.35	81.07	28.71	80.94	29.06	86
87	82.26	28.32	82.14	28.68	82.01	29.04	81.88	29.40	87
88	83.21	28.65	83.08	29.01	82.95	29.37	82.82	29.74	88
89	84.15	28.98	84.02	29.34	83.90	29.71	83.76	30.07	89
90	85.10	29.30	84.97	29.67	84.84	30.04	84.71	30.41	90
91	86.04	29.63	85.91	30.00	85.78	30.38	85.65	30.75	91
92	86.99	29.95	86.86	30.33	86.72	30.71	86.59	31.09	92
93	87.93	30.28	87.80	30.66	87.67	31.04	87.53	31.43	93
94	88.88	30.60	88.74	30.99	88.61	31.38	88.47	31.76	94
95	89.82	30.93	89.69	31.32	89.55	31.71	89.41	32.10	95
96	90.77	31.25	90.63	31.65	90.49	32.05	90.35	32.44	96
97	91.72	31.58	91.58	31.98	91.44	32.38	91.29	32.78	97
98	92.66	31.91	92.52	32.31	92.38	32.71	92.24	33.12	98
99	93.61	32.23	93.46	32.64	93.32	33.05	93.18	33.45	99
100	94.55	32.56	94.41	32.97	94.26	33.38	94.12	33.79	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	71 Deg.		70¾ Deg.		70½ Deg.		70¼ Deg.		

Distance.	20 Deg.		20¼ Deg.		20½ Deg.		20¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.94	0.34	0.94	0.35	0.94	0.35	0.94	0.35	1
2	1.88	0.68	1.88	0.69	1.87	0.70	1.87	0.71	2
3	2.82	1.03	2.81	1.04	2.81	1.05	2.81	1.06	3
4	3.76	1.37	3.75	1.38	3.75	1.40	3.74	1.42	4
5	4.70	1.71	4.69	1.73	4.68	1.75	4.68	1.77	5
6	5.64	2.05	5.63	2.08	5.62	2.10	5.61	2.13	6
7	6.58	2.39	6.57	2.42	6.56	2.45	6.55	2.48	7
8	7.52	2.74	7.51	2.77	7.49	2.80	7.48	2.83	8
9	8.46	3.08	8.44	3.12	8.43	3.15	8.42	3.19	9
10	9.40	3.42	9.38	3.46	9.37	3.50	9.35	3.54	10
11	10.34	3.76	10.32	3.81	10.30	3.85	10.29	3.90	11
12	11.28	4.10	11.26	4.15	11.24	4.20	11.22	4.25	12
13	12.22	4.45	12.20	4.50	12.18	4.55	12.16	4.61	13
14	13.16	4.79	13.13	4.85	13.11	4.90	13.09	4.96	14
15	14.10	5.13	14.07	5.19	14.05	5.25	14.03	5.31	15
16	15.04	5.47	15.01	5.54	14.99	5.60	14.96	5.67	16
17	15.97	5.81	15.95	5.88	15.92	5.95	15.90	6.02	17
18	16.91	6.16	16.89	6.23	16.86	6.30	16.83	6.38	18
19	17.85	6.50	17.83	6.58	17.80	6.65	17.77	6.73	19
20	18.79	6.84	18.76	6.92	18.73	7.00	18.70	7.09	20
21	19.73	7.18	19.70	7.27	19.67	7.35	19.64	7.44	21
22	20.67	7.52	20.64	7.61	20.61	7.70	20.57	7.79	22
23	21.61	7.87	21.58	7.96	21.54	8.05	21.51	8.15	23
24	22.55	8.21	22.52	8.31	22.48	8.40	22.44	8.50	24
25	23.49	8.55	23.45	8.65	23.42	8.76	23.38	8.86	25
26	24.43	8.89	24.39	9.00	24.35	9.11	24.31	9.21	26
27	25.37	9.23	25.33	9.35	25.29	9.46	25.25	9.57	27
28	26.31	9.58	26.27	9.69	26.23	9.81	26.18	9.92	28
29	27.25	9.92	27.21	10.04	27.16	10.16	27.12	10.27	29
30	28.19	10.26	28.15	10.38	28.10	10.51	28.05	10.63	30
31	29.13	10.60	29.08	10.73	29.04	10.86	28.99	10.98	31
32	30.07	10.94	30.02	11.08	29.97	11.21	29.92	11.34	32
33	31.01	11.29	30.96	11.42	30.91	11.56	30.86	11.69	33
34	31.95	11.63	31.90	11.77	31.85	11.91	31.79	12.05	34
35	32.89	11.97	32.84	12.11	32.78	12.26	32.73	12.40	35
36	33.83	12.31	33.77	12.46	33.72	12.61	33.66	12.75	36
37	34.77	12.65	34.71	12.81	34.66	12.96	34.60	13.11	37
38	35.71	13.00	35.65	13.15	35.59	13.31	35.54	13.46	38
39	36.65	13.34	36.59	13.50	36.53	13.66	36.47	13.82	39
40	37.59	13.68	37.53	13.84	37.47	14.01	37.41	14.17	40
41	38.53	14.02	38.47	14.19	38.40	14.36	38.34	14.53	41
42	39.47	14.36	39.40	14.54	39.34	14.71	39.28	14.88	42
43	40.41	14.71	40.34	14.88	40.28	15.06	40.21	15.23	43
44	41.35	15.05	41.28	15.23	41.21	15.41	41.15	15.59	44
45	42.29	15.39	42.22	15.58	42.15	15.76	42.08	15.94	45
46	43.23	15.73	43.16	15.92	43.09	16.11	43.02	16.30	46
47	44.17	16.07	44.09	16.27	44.02	16.46	43.95	16.65	47
48	45.11	16.42	45.03	16.61	44.96	16.81	44.89	17.01	48
49	46.04	16.76	45.97	16.96	45.90	17.16	45.82	17.36	49
50	46.98	17.10	46.91	17.31	46.83	17.51	46.76	17.71	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	70 Deg.		69¾ Deg.		69½ Deg.		69¼ Deg.		

Distance.	20 Deg.		20¼ Deg.		20½ Deg.		20¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	47.92	17.44	47.85	17.65	47.77	17.86	47.69	18.07	51
52	48.86	17.79	48.79	18.00	48.71	18.21	48.63	18.42	52
53	49.80	18.13	49.72	18.34	49.64	18.56	49.56	18.78	53
54	50.74	18.47	50.66	18.69	50.58	18.91	50.50	19.13	54
55	51.68	18.81	51.60	19.04	51.52	19.26	51.43	19.49	55
56	52.62	19.15	52.54	19.38	52.45	19.61	52.37	19.84	56
57	53.56	19.50	53.48	19.73	53.39	19.96	53.30	20.19	57
58	54.50	19.84	54.42	20.07	54.33	20.31	54.24	20.55	58
59	55.44	20.18	55.35	20.42	55.26	20.66	55.17	20.90	59
60	56.38	20.52	56.29	20.77	56.20	21.01	56.11	21.26	60
61	57.32	20.86	57.23	21.11	57.14	21.36	57.04	21.61	61
62	58.26	21.21	58.17	21.46	58.07	21.71	57.98	21.97	62
63	59.20	21.55	59.11	21.81	59.01	22.06	58.91	22.32	63
64	60.14	21.89	60.04	22.15	59.95	22.41	59.85	22.67	64
65	61.08	22.23	60.98	22.50	60.88	22.76	60.78	23.03	65
66	62.02	22.57	61.92	22.84	61.82	23.11	61.72	23.38	66
67	62.96	22.92	62.86	23.19	62.76	23.46	62.65	23.74	67
68	63.90	23.26	63.80	23.54	63.69	23.81	63.59	24.09	68
69	64.84	23.60	64.74	23.88	64.63	24.16	64.52	24.45	69
70	65.78	23.94	65.67	24.23	65.57	24.51	65.46	24.80	70
71	66.72	24.28	66.61	24.57	66.50	24.86	66.39	25.15	71
72	67.66	24.63	67.55	24.92	67.44	25.21	67.33	25.51	72
73	68.60	24.97	68.49	25.27	68.38	25.57	68.26	25.86	73
74	69.54	25.31	69.43	25.61	69.31	25.92	69.20	26.22	74
75	70.48	25.65	70.36	25.96	70.25	26.27	70.14	26.57	75
76	71.42	25.99	71.30	26.30	71.19	26.62	71.07	26.93	76
77	72.36	26.34	72.24	26.65	72.12	26.97	72.01	27.28	77
78	73.30	26.68	73.18	27.00	73.06	27.32	72.94	27.63	78
79	74.24	27.02	74.12	27.34	74.00	27.67	73.88	27.99	79
80	75.18	27.36	75.06	27.69	74.93	28.02	74.81	28.34	80
81	76.12	27.70	75.99	28.04	75.87	28.37	75.75	28.70	81
82	77.05	28.05	76.93	28.38	76.81	28.72	76.68	29.05	82
83	77.99	28.39	77.87	28.73	77.74	29.07	77.62	29.41	83
84	78.93	28.73	78.81	29.07	78.68	29.42	78.55	29.76	84
85	79.87	29.07	79.75	29.42	79.62	29.77	79.49	30.11	85
86	80.81	29.41	80.68	29.77	80.55	30.12	80.42	30.47	86
87	81.75	29.76	81.62	30.11	81.49	30.47	81.36	30.82	87
88	82.69	30.10	82.56	30.46	82.43	30.82	82.29	31.18	88
89	83.63	30.44	83.50	30.80	83.36	31.17	83.23	31.53	89
90	84.57	30.78	84.44	31.15	84.30	31.52	84.16	31.89	90
91	85.51	31.12	85.38	31.50	85.24	31.87	85.10	32.24	91
92	86.45	31.47	86.31	31.84	86.17	32.22	86.03	32.59	92
93	87.39	31.81	87.25	32.19	87.11	32.57	86.97	32.95	93
94	88.33	32.15	88.19	32.54	88.05	32.92	87.90	33.30	94
95	89.27	32.49	89.13	32.88	88.98	33.27	88.84	33.66	95
96	90.21	32.83	90.07	33.23	89.92	33.62	89.77	34.01	96
97	91.15	33.18	91.00	33.57	90.86	33.97	90.71	34.37	97
98	92.09	33.52	91.94	33.92	91.79	34.32	91.64	34.72	98
99	93.03	33.86	92.88	34.27	92.73	34.67	92.58	35.07	99
100	93.97	34.20	93.82	34.61	93.67	35.02	93.51	35.43	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	70 Deg.		69¾ Deg.		69½ Deg.		69¼ Deg.		

Distance.	21 Deg.		21¼ Deg.		21½ Deg.		21¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.93	0.36	0.93	0.36	0.93	0.37	0.93	0.37	1
2	1.87	0.72	1.86	0.72	1.86	0.73	1.86	0.74	2
3	2.80	1.08	2.80	1.09	2.79	1.10	2.79	1.11	3
4	3.73	1.43	3.73	1.45	3.72	1.47	3.72	1.48	4
5	4.67	1.79	4.66	1.81	4.65	1.83	4.64	1.85	5
6	5.60	2.15	5.59	2.17	5.58	2.20	5.57	2.22	6
7	6.54	2.51	6.52	2.54	6.51	2.57	6.50	2.59	7
8	7.47	2.87	7.46	2.90	7.44	2.93	7.43	2.96	8
9	8.40	3.23	8.39	3.26	8.37	3.30	8.36	3.34	9
10	9.34	3.58	9.32	3.62	9.30	3.67	9.29	3.71	10
11	10.27	3.94	10.25	3.99	10.23	4.03	10.22	4.08	11
12	11.20	4.30	11.18	4.35	11.17	4.40	11.15	4.45	12
13	12.14	4.66	12.12	4.71	12.10	4.76	12.07	4.82	13
14	13.07	5.02	13.05	5.07	13.03	5.13	13.00	5.19	14
15	14.00	5.38	13.98	5.44	13.96	5.50	13.93	5.56	15
16	14.94	5.73	14.91	5.80	14.89	5.86	14.86	5.93	16
17	15.87	6.09	15.84	6.16	15.82	6.23	15.79	6.30	17
18	16.80	6.45	16.78	6.52	16.75	6.60	16.72	6.67	18
19	17.74	6.81	17.71	6.89	17.68	6.96	17.65	7.04	19
20	18.67	7.17	18.64	7.25	18.61	7.33	18.58	7.41	20
21	19.61	7.53	19.57	7.61	19.54	7.70	19.50	7.78	21
22	20.54	7.88	20.50	7.97	20.47	8.06	20.43	8.15	22
23	21.47	8.24	21.44	8.34	21.40	8.43	21.36	8.52	23
24	22.41	8.60	22.37	8.70	22.33	8.80	22.29	8.89	24
25	23.34	8.96	23.30	9.06	23.26	9.16	23.22	9.26	25
26	24.27	9.32	24.23	9.42	24.19	9.53	24.15	9.63	26
27	25.21	9.68	25.16	9.79	25.12	9.90	25.08	10.01	27
28	26.14	10.03	26.10	10.15	26.05	10.26	26.01	10.38	28
29	27.07	10.39	27.03	10.51	26.98	10.63	26.94	10.75	29
30	28.01	10.75	27.96	10.87	27.91	11.00	27.86	11.12	30
31	28.94	11.11	28.89	11.24	28.84	11.36	28.79	11.49	31
32	29.87	11.47	29.82	11.60	29.77	11.73	29.72	11.86	32
33	30.81	11.83	30.76	11.96	30.70	12.09	30.65	12.23	33
34	31.74	12.18	31.69	12.32	31.63	12.46	31.58	12.60	34
35	32.68	12.54	32.62	12.69	32.56	12.83	32.51	12.97	35
36	33.61	12.90	33.55	13.05	33.50	13.19	33.44	13.34	36
37	34.54	13.26	34.48	13.41	34.43	13.56	34.37	13.71	37
38	35.48	13.62	35.42	13.77	35.36	13.93	35.29	14.08	38
39	36.41	13.98	36.35	14.14	36.29	14.29	36.22	14.45	39
40	37.34	14.33	37.28	14.50	37.22	14.66	37.15	14.82	40
41	38.28	14.69	38.21	14.86	38.15	15.03	38.08	15.19	41
42	39.21	15.05	39.14	15.22	39.08	15.39	39.01	15.56	42
43	40.14	15.41	40.08	15.58	40.01	15.76	39.94	15.93	43
44	41.08	15.77	41.01	15.95	40.94	16.13	40.87	16.30	44
45	42.01	16.13	41.94	16.31	41.87	16.49	41.80	16.68	45
46	42.94	16.48	42.87	16.67	42.80	16.86	42.73	17.05	46
47	43.88	16.84	43.80	17.03	43.73	17.23	43.65	17 42	47
48	44.81	17.20	44.74	17.40	44.66	17.59	44.58	17.79	48
49	45.75	17.56	45.67	17.76	45.59	17.96	45.51	18.16	49
50	46.68	17.92	46.60	18.12	46.52	18.33	46.44	18.53	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	69 Deg.		68¾ Deg.		68½ Deg.		68¼ Deg.		

Distance.	21 Deg.		21¼ Deg.		21½ Deg.		21¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	47.61	18.28	47.53	18.48	47.45	18.69	47.37	18.90	51
52	48.55	18.64	48.46	18.85	48.38	19.06	48.30	19.27	52
53	49.48	18.99	49.40	19.21	49.31	19.42	49.23	19.64	53
54	50.41	19.35	50.33	19.57	50.24	19.79	50.16	20.01	54
55	51.35	19.71	51.26	19.93	51.17	20.16	51.08	20.38	55
56	52.28	20.07	52.19	20.30	52.10	20.52	52.01	20.75	56
57	53.21	20.43	53.12	20.66	53.03	20.89	52.94	21.12	57
58	54.15	20.79	54.06	21.02	53.96	21.26	53.87	21.49	58
59	55.08	21.14	54.99	21.38	54.89	21.62	54.80	21.86	59
60	56.01	21.50	55.92	21.75	55.83	21.99	55.73	22.23	60
61	56.95	21.86	56.85	22.11	56.76	22.36	56.66	22.60	61
62	57.88	22.22	57.78	22.47	57.69	22.72	57.59	22.97	62
63	58.82	22.58	58.72	22.83	58.62	23.09	58.52	23.35	63
64	59.75	22.94	59.65	23.20	59.55	23.46	59.44	23.72	64
65	60.68	23.29	60.58	23.56	60.48	23.82	60.37	24.09	65
66	61.62	23.65	61.51	23.92	61.41	24.19	61.30	24.46	66
67	62.55	24.01	62.44	24.28	62.34	24.56	62.23	24.83	67
68	63.48	24.37	63.38	24.65	63.27	24.92	63.16	25.20	68
69	64.42	24.73	64.31	25.01	64.20	25.29	64.09	25.57	69
70	65.35	25.09	65.24	25.37	65.13	25.66	65.02	25.94	70
71	66.28	25.44	66.17	25.73	66.06	26.02	65.95	26.31	71
72	67.22	25.80	67.10	26.10	66.99	26.39	66.87	26.68	72
73	68.15	26.16	68.04	26.46	67.92	26.75	67.80	27.05	73
74	69.08	26.52	68.97	26.82	68.85	27.12	68.73	27.42	74
75	70.02	26.88	69.90	27.18	69.78	27.49	69.66	27.79	75
76	70.95	27.24	70.83	27.55	70.71	27.85	70.59	28.16	76
77	71.89	27.59	71.76	27.91	71.64	28.22	71.52	28.53	77
78	72.82	27.95	72.70	28.27	72.57	28.59	72.45	28.90	78
79	73.75	28.31	73.63	28.63	73.50	28.95	73.38	29.27	79
80	74.69	28.67	74.56	29.00	74.43	29.32	74.30	29.64	80
81	75.62	29.03	75.49	29.36	75.36	29.69	75.23	30.02	81
82	76.55	29.39	76.42	29.72	76.29	30.05	76.16	30.39	82
83	77.49	29.74	77.36	30.08	77.22	30.42	77.09	30.76	83
84	78.42	30.10	78.29	30.44	78.16	30.79	78.02	31.13	84
85	79.35	30.46	79.22	30.81	79.09	31.15	78.95	31.50	85
86	80.29	30.82	80.15	31.17	80.02	31.52	79.88	31.87	86
87	81.22	31.18	81.08	31.53	80.95	31.89	80.81	32.24	87
88	82.16	31.54	82.02	31.89	81.88	32.25	81.74	32.61	88
89	83.09	31.89	82.95	32.26	82.81	32.62	82.66	32.98	89
90	84.02	32.25	83.88	32.62	83.74	32.99	83.59	33.35	90
91	84.96	32.61	84.81	32.98	84.67	33.35	84.52	33.72	91
92	85.89	32.97	85.74	33.34	85.60	33.72	85.45	34.09	92
93	86.82	33.33	86.68	33.71	86.53	34.08	86.38	34.46	93
94	87.76	33.69	87.61	34.07	87.46	34.45	87.31	34.83	94
95	88.69	34.04	88.54	34.43	88.39	34.82	88.24	35.20	95
96	89.62	34.40	89.47	34.79	89.32	35.18	89.17	35.57	96
97	90.56	34.76	90.40	35.16	90.25	35.55	90.09	35.94	97
98	91.49	35.12	91.34	35.52	91.18	35.92	91.02	36.31	98
99	92.42	35.48	92.27	35.88	92.11	36.28	91.95	36.69	99
100	93.36	35.84	93.20	36.24	93.04	36.65	92.88	37.06	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	69 Deg.		68¾ Deg.		68½ Deg.		68¼ Deg.		

Distance.	22 Deg.		22¼ Deg.		22½ Deg.		22¾ Deg.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	0.93	0.37	0.93	0.38	0.92	0.38	0.92	0.39
2	1.85	0.75	1.85	0.76	1.85	0.77	1.84	0.77
3	2.78	1.12	2.78	1.14	2.77	1.15	2.77	1.16
4	3.71	1.50	3.70	1.51	3.70	1.53	3.69	1.55
5	4.64	1.87	4.63	1.89	4.62	1.91	4.61	1.93
6	5.56	2.25	5.55	2.27	5.54	2.30	5.53	2.32
7	6.49	2.62	6.48	2.65	6.47	2.68	6.46	2.71
8	7.42	3.00	7.40	3.03	7.39	3.06	7.38	3.09
9	8.34	3.37	8.33	3.41	8.31	3.44	8.30	3.48
10	9.27	3.75	9.26	3.79	9.24	3.83	9.22	3.87
11	10.20	4.12	10.18	4.17	10.16	4.21	10.14	4.25
12	11.13	4.50	11.11	4.54	11.09	4.59	11.07	4.64
13	12.05	4.87	12.03	4.92	12.01	4.97	11.99	5.03
14	12.98	5.24	12.96	5.30	12.93	5.36	12.91	5.41
15	13.91	5.62	13.88	5.68	13.86	5.74	13.83	5.80
16	14.83	5.99	14.81	6.06	14.78	6.12	14.76	6.19
17	15.76	6.37	15.73	6.44	15.71	6.51	15.68	6.57
18	16.69	6.74	16.66	6.82	16.63	6.89	16.60	6.96
19	17.62	7.12	17.59	7.19	17.55	7.27	17.52	7.35
20	18.54	7.49	18.51	7.57	18.48	7.65	18.44	7.73
21	19.47	7.87	19.44	7.95	19.40	8.04	19.37	8.12
22	20.40	8.24	20.36	8.33	20.33	8.42	20.29	8.51
23	21.33	8.62	21.29	8.71	21.25	8.80	21.21	8.89
24	22.25	8.99	22.21	9.09	22.17	9.18	22.13	9.28
25	23.18	9.37	23.14	9.47	23.10	9.57	23.05	9.67
26	24.11	9.74	24.06	9.84	24.02	9.95	23.98	10.05
27	25.03	10.11	24.99	10.22	24.94	10.33	24.90	10.44
28	25.96	10.49	25.92	10.60	25.87	10.72	25.82	10.83
29	26.89	10.86	26.84	10.98	26.79	11.10	26.74	11.21
30	27.82	11.24	27.77	11.36	27.72	11.48	27.67	11.60
31	28.74	11.61	28.69	11.74	28.64	11.86	28.59	11.99
32	29.67	11.99	29.62	12.12	29.56	12.25	29.51	12.37
33	30.60	12.36	30.54	12.50	30.49	12.63	30.43	12.76
34	31.52	12.74	31.47	12.87	31.41	13.01	31.35	13.15
35	32.45	13.11	32.39	13.25	32.34	13.39	32.28	13.53
36	33.38	13.49	33.32	13.63	33.26	13.78	33.20	13.92
37	34.31	13.86	34.24	14.01	34.18	14.16	34.12	14.31
28	35.23	14.24	35.17	14.39	35.11	14.54	35.04	14.70
39	36.16	14.61	36.10	14.77	36.03	14.92	35.97	15.08
40	37.09	14.98	37.02	15.15	36.96	15.31	36.89	15.47
41	38.01	15.36	37.95	15.52	37.88	15.69	37.81	15.86
42	38.94	15.73	38.87	15.90	38.80	16.07	38.73	16.24
43	39.87	16.11	39.80	16.28	39.73	16.46	39.65	16.63
44	40.80	16.48	40.72	16.66	40.65	16.84	40.58	17.02
45	41.72	16.86	41.65	17.04	41.57	17.22	41.50	17.40
46	42.65	17.23	42.57	17.42	42.50	17.60	42.42	17.79
47	43.58	17.61	43.50	17.80	43.42	17.99	43.34	18.18
48	44.50	17.98	44.43	18.18	44.35	18.37	44.27	18.56
49	45.43	18.36	45.35	18.55	45.27	18.75	45.19	18.95
50	46.36	18.73	46.28	18.93	46.19	19.13	46.11	19.34
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	63 Deg.		67¾ Deg.		67½ Deg.		67¼ Deg.	

Distance.	22 Deg.		22¼ Deg.		22½ Deg.		22¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	47.29	19.10	47.20	19.31	47.12	19.52	47.03	19.72	51
52	48.21	19.48	48.13	19.69	48.04	19.90	47.95	20.11	52
53	49.14	19.85	49.05	20.07	48.97	20.28	48.88	20.50	53
54	50.07	20.23	49.98	20.45	49.89	20.66	49.80	20.88	54
55	51.00	20.60	50.90	20.83	50.81	21.05	50.72	21.27	55
56	51.92	20.98	51.83	21.20	51.74	21.43	51.64	21.66	56
57	52.85	21.35	52.76	21.58	52.66	21.81	52.57	22.04	57
58	53.78	21.73	53.68	21.96	53.59	22.20	53.49	22.43	58
59	54.70	22.10	54.61	22.34	54.51	22.58	54.41	22.82	59
60	55.63	22.48	55.53	22.72	55.43	22.96	55.33	23.20	60
61	56.56	22.85	56.47	23.10	56.36	23.34	56.25	23.59	61
62	57.49	23.23	57.33	23.48	57.28	23.73	57.18	23.98	62
63	58.41	23.60	58.31	23.85	58.20	24.11	58.10	24.36	63
64	59.34	23.97	59.23	24.23	59.13	24.49	59.02	24.75	64
65	60.27	24.35	60.16	24.61	60.05	24.87	59.94	25.14	65
66	61.19	24.72	61.09	24.99	60.98	25.26	60.87	25.52	66
67	62.12	25.10	62.01	25.37	61.90	25.64	61.79	25.91	67
68	63.05	25.47	62.94	25.75	62.82	26.02	62.71	26.30	68
69	63.98	25.85	63.86	26.13	63.75	26.41	63.63	26.68	69
70	64.90	26.22	64.79	26.51	64.67	26.79	64.55	27.07	70
71	65.83	26.60	65.71	26.88	65.60	27.17	65.48	27.46	71
72	66.76	26.97	66.64	27.26	66.52	27.55	66.40	27.84	72
73	67.68	27.35	67.56	27.64	67.44	27.94	67.32	28.23	73
74	68.61	27.72	68.49	28.02	68.37	28.32	68.24	28.62	74
75	69.54	28.10	69.42	28.40	69.29	28.70	69.17	29.00	75
76	70.47	28.47	70.34	28.78	70.21	29.08	70.09	29.39	76
77	71.39	28.84	71.27	29.16	71.14	29.47	71.01	29.78	77
78	72.32	29.22	72.19	29.53	72.06	29.85	71.93	30.16	78
79	73.25	29.59	73.12	29.91	72.99	30.23	72.85	30.55	79
80	74.17	29.97	74.04	30.29	73.91	30.61	73.78	30.94	80
81	75.10	30.34	74.97	30.67	74.83	31.00	74.70	31.32	81
82	76.03	30.72	75.89	31.05	75.76	31.38	75.62	31.71	82
83	76.96	31.09	76.82	31.43	76.68	31.76	76.54	32.10	83
84	77.88	31.47	77.75	31.81	77.61	32.15	77.46	32.48	84
85	78.81	31.84	78.67	32.19	78.53	32.53	78.39	32.87	85
86	79.74	32.22	79.60	32.56	79.45	32.91	79.31	33.26	86
87	80.66	32.59	80.52	32.94	80.38	33.29	80.23	33.64	87
88	81.59	32.97	81.45	33.32	81.30	33.68	81.15	34.03	88
89	82.52	33.34	82.37	33.70	82.23	34.06	82.08	34.42	89
90	83.45	33.71	83.30	34.08	83.15	34.44	83.00	34.80	90
91	84.37	34.09	84.22	34.46	84.07	34.82	83.92	35.19	91
92	85.30	34.46	85.15	34.84	85.00	35.21	84.84	35.58	92
93	86.23	34.84	86.08	35.21	85.92	35.59	85.76	35.96	93
94	87.16	35.21	87.00	35.59	86.84	35.97	86.69	36.35	94
95	88.08	35.59	87.93	35.97	87.77	36.35	87.61	36.74	95
96	89.01	35.96	88.85	36.35	88.69	36.74	88.53	37.12	96
97	89.94	36.34	89.78	36.73	89.62	37.12	89.45	37.51	97
98	90.86	36.71	90.70	37.11	90.54	37.50	90.38	37.90	98
99	91.79	37.09	91.63	37.49	91.46	37.89	91.30	38.28	99
100	92.72	37.46	92.55	37.86	92.39	38.27	92.22	38.67	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	68 Deg.		67¾ Deg.		67½ Deg.		67¼ Deg.		

Distance.	23 Deg.		23¼ Deg.		23½ Deg.		23¾ Deg.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	D
1	0.92	0.39	0.92	0.39	0.92	0.40	0.92	0.
2	1.84	0.78	1.84	0.79	1.83	0.80	1.83	0.
3	2.76	1.17	2.76	1.18	2.75	1.20	2.75	1.
4	3.68	1.56	3.68	1.58	3.67	1.59	3.66	1.
5	4.60	1.95	4.59	1.97	4.59	1.99	4.58	2.
6	5.52	2.34	5.51	2.37	5.50	2.39	5.49	2.
7	6.44	2.74	6.43	2.76	6.42	2.79	6.41	2.
8	7.36	3.13	7.35	3.16	7.34	3.19	7.32	3.
9	8.28	3.52	8.27	3.55	8.25	3.59	8.24	3.
10	9.20	3.91	9.19	3.95	9.17	3.99	9.15	4.
11	10.13	4.30	10.11	4.34	10.09	4.39	10.07	4.
12	11.05	4.69	11.03	4.74	11.00	4.78	10.98	4.
13	11.97	5.08	11.94	5.13	11.92	5.18	11.90	5.
14	12.89	5.47	12.86	5.53	12.84	5.58	12.81	5.
15	13.81	5.86	13.78	5.92	13.76	5.98	13.73	6.
16	14.73	6.25	14.70	6.32	14.67	6.38	14.64	6.
17	15.65	6.64	15.62	6.71	15.59	6.78	15.56	6.
18	16.57	7.03	16.54	7.11	16.51	7.18	16.48	7.
19	17.49	7.42	17.46	7.50	17.42	7.58	17.39	7.
20	18.41	7.81	18.38	7.89	18.34	7.97	18.31	8.
21	19.33	8.21	19.29	8.29	19.26	8.37	19.22	8.
22	20.25	8.60	20.21	8.68	20.18	8.77	20.14	8.
23	21.17	8.99	21.13	9.08	21.09	9.17	21.05	9
24	22.09	9.38	22.05	9.47	22.01	9.57	21.97	9.
25	23.01	9.77	22.97	9.87	22.93	9.97	22.88	10.
26	23.93	10.16	23.89	10.26	23.84	10.37	23.80	10.
27	24.85	10.55	24.81	10.66	24.76	10.77	24.71	10.
28	25.77	10.94	25.73	11.05	25.68	11.16	25.63	11.
29	26.69	11.33	26.64	11.45	26.59	11.56	26.54	11.
30	27.62	11.72	27.56	11.84	27.51	11.96	27.46	12.
31	28.54	12.11	28.48	12.24	28.43	12.36	28.37	12.
32	29.46	12.50	29.40	12.63	29.35	12.76	29.29	12.
33	30.38	12.89	30.32	13.03	30.26	13.16	30.21	13.
34	31.30	13.28	31.24	13.42	31.18	13.56	31.12	13.
35	32.22	13.68	32.16	13.82	32.10	13.96	32.04	14.
36	33.14	14.07	33.08	14.21	33.01	14.35	32.95	14.
37	34.06	14.46	34.00	14.61	33.93	14.75	33.87	14.
38	34.98	14.85	34.91	15.00	34.85	15.15	34.78	15.
39	35.90	15.24	35.83	15.39	35.77	15.55	35.70	15.
40	36.82	15.63	36.75	15.79	36.68	15.95	36.61	16.
41	37.74	16.02	37.67	16.18	37.60	16.35	37.53	16.
42	38.66	16.41	38.59	16.58	38.52	16.75	38.44	16.
43	39.58	16.80	39.51	16.97	39.43	17.15	39.36	17.
44	40.50	17.19	40.43	17.37	40.35	17.54	40.27	17.
45	41.42	17.58	41.35	17.76	41.27	17.94	41.19	18.
46	42.34	17.97	42.26	18.16	42.18	18.34	42.10	18.
47	43.26	18.36	43.18	18.55	43.10	18.74	43.02	18.
48	44.18	18.76	44.10	18.95	44.02	19.14	43.93	19.
49	45.10	19.15	45.02	19.34	44.94	19.54	44.85	19.
50	46.03	19.54	45.94	19.74	45.85	19.94	45.77	20.
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	La
	67 Deg.		66¾ Deg.		66½ Deg.		66¼ Deg.	

Distance.	23 Deg.		23¼ Deg.		23½ Deg.		23¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	46.95	19.93	46.86	20.13	46.77	20.34	46.68	20.54	51
52	47.87	20.32	47.78	20.53	47.69	20.73	47.60	20.94	52
53	48.79	20.71	48.70	20.92	48.60	21.13	48.51	21.35	53
54	49.71	21.10	49.61	21.32	49.52	21.53	49.43	21.75	54
55	50.63	21.49	50.53	21.71	50.44	21.93	50.34	22.15	55
56	51.55	21.88	51.45	22.11	51.36	22.33	51.26	22.55	56
57	52.47	22.27	52.37	22.50	52.27	22.73	52.17	22.96	57
58	53.39	22.66	53.29	22.90	53.19	23.13	53.09	23.36	58
59	54.31	23.05	54.21	23.29	54.11	23.53	54.00	23.76	59
60	55.23	23.44	55.13	23.68	55.02	23.92	54.92	24.16	60
61	56.15	23.83	56.05	24.08	55.94	24.32	55.83	24.57	61
62	57.07	24.23	56.97	24.47	56.86	24.72	56.75	24.97	62
63	57.99	24.62	57.88	24.87	57.77	25.12	57.66	25.37	63
64	58.91	25.01	58.80	25.26	58.69	25.52	58.58	25.78	64
65	59.83	25.40	59.72	25.66	59.61	25.92	59.50	26.18	65
66	60.75	25.79	60.64	26.05	60.53	26.32	60.41	26.58	66
67	61.67	26.18	61.56	26.45	61.44	26.72	61.33	26.98	67
68	62.59	26.57	62.48	26.84	62.36	27.11	62.24	27.39	68
69	63.51	26.96	63.40	27.24	63.28	27.51	63.16	27.79	69
70	64.44	27.35	64.32	27.63	64.19	27.91	64.07	28.19	70
71	65.36	27.74	65.23	28.03	65.11	28.31	64.99	28.59	71
72	66.28	28.13	66.15	28.42	66.03	28.71	65.90	29.00	72
73	67.20	28.52	67.07	28.82	66.95	29.11	66.82	29.40	73
74	68.12	28.91	67.99	29.21	67.86	29.51	67.73	29.80	74
75	69.04	29.30	68.91	29.61	68.78	29.91	68.65	30.21	75
76	69.96	29.70	69.83	30.00	69.70	30.30	69.56	30.61	76
77	70.88	30.09	70.75	30.40	70.61	30.70	70.48	31.01	77
78	71.80	30.48	71.67	30.79	71.53	31.10	71.39	31.41	78
79	72.72	30.87	72.58	31.18	72.45	31.50	72.31	31.82	79
80	73.64	31.26	73.50	31.58	73.36	31.90	73.22	32.22	80
81	74.56	31.65	74.42	31.97	74.28	32.30	74.14	32.62	81
82	75.48	32.04	75.34	32.37	75.20	32.70	75.06	33.03	82
83	76.40	32.43	76.26	32.76	76.12	33.10	75.97	33.43	83
84	77.32	32.82	77.18	33.16	77.03	33.49	76.89	33.83	84
85	78.24	33.21	78.10	33.55	77.95	33.89	77.80	34.23	85
86	79.16	33.60	79.02	33.95	78.87	34.29	78.72	34.64	86
87	80.08	33.99	79.93	34.34	79.78	34.69	79.63	35.04	87
88	81.00	34.38	80.85	34.74	80.70	35.09	80.55	35.44	88
89	81.92	34.78	81.77	35.13	81.62	35.49	81.46	35.84	89
90	82.85	35.17	82.69	35.53	82.54	35.89	82.38	36.25	90
91	83.77	35.56	83.61	35.92	83.45	36.29	83.29	36.65	91
92	84.69	35.95	84.53	36.32	84.37	36.68	84.21	37.05	92
93	85.61	36.34	85.45	36.71	85.29	37.08	85.12	37.46	93
94	86.53	36.73	86.37	37.11	86.20	37.48	86.04	37.86	94
95	87.45	37.12	87.29	37.50	87.12	37.88	86.95	38.26	95
96	88.37	37.51	88.20	37.90	88.04	38.28	87.87	38.66	96
97	89.29	37.90	89.12	38.29	88.95	38.68	88.79	39.07	97
98	90.21	38.29	90.04	38.68	89.87	39.08	89.70	39.47	98
99	91.13	38.68	90.96	39.08	90.79	39.48	90.62	39.87	99
100	92.05	39.07	91.88	39.47	91.71	39.87	91.53	40.27	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	67 Deg.		66¾ Deg.		66½ Deg.		66¼ Deg.		

Distance.	24 Deg.		24¼ Deg.		24½ Deg.		24¾ Deg.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep
1	0.91	0.41	0.91	0.41	0.91	0.41	0.91	0.
2	1.83	0.81	1.82	0.82	1.82	0.83	1.82	0.
3	2.74	1.22	2.74	1.23	2.73	1.24	2.72	1.
4	3.65	1.63	3.65	1.64	3.64	1.66	3.63	1.
5	4.57	2.03	4.56	2.05	4.55	2.07	4.54	2.
6	5.48	2.44	5.47	2.46	5.46	2.49	5.45	2.
7	6.39	2.85	6.38	2.87	6.37	2.90	6.36	2.
8	7.31	3.25	7.29	3.29	7.28	3.32	7.27	3.
9	8.22	3.66	8.21	3.70	8.19	3.73	8.17	3.
10	9.14	4.07	9.12	4.11	9.10	4.15	9.08	4.
11	10.05	4.47	10.03	4.52	10.01	4.56	9.99	4.
12	10.96	4.88	10.94	4.93	10.92	4.98	10.90	5.
13	11.88	5.29	11.85	5.34	11.83	5.39	11.81	5.
14	12.79	5.69	12.76	5.75	12.74	5.81	12.71	5.
15	13.70	6.10	13.68	6.16	13.65	6.22	13.62	6.
16	14.62	6.51	14.59	6.57	14.56	6.64	14.53	6.
17	15.53	6.92	15.50	6.98	15.47	7.05	15.44	7.
18	16.44	7.32	16.41	7.39	16.38	7.46	16.35	7.
19	17.36	7.73	17.32	7.80	17.29	7.88	17.25	7.
20	18.27	8.13	18.24	8.21	18.20	8.29	18.16	8.
21	19.18	8.54	19.15	8.63	19.11	8.71	19.07	8.
22	20.10	8.95	20.06	9.04	20.02	9.12	19.98	9.
23	21.01	9.35	20.97	9.45	20.93	9.54	20.89	9.
24	21.93	9.76	21.88	9.86	21.84	9.95	21.80	10.
25	22.84	10.17	22,79	10.27	22.75	10.37	22.70	10.
26	23.75	10.58	23.71	10.68	23.66	10.78	23.61	10.
27	24.67	10.98	24.62	11.09	24.57	11.20	24.52	11.
28	25.58	11.39	25.53	11.50	25.48	11.61	25.43	11.
29	26.49	11.80	26.44	11.91	26.39	12.03	26.34	12.
30	27.41	12.20	27.35	12.32	27.30	12.44	27.24	12.
31	28.32	12.61	28.26	12.73	28.21	12.86	28.15	12.
32	29.23	13.02	29.18	13.14	29.12	13.27	29.06	13.
33	30.15	13.42	30.09	13.55	30.03	13.68	29.97	13.
34	31.06	13.83	31.00	13.96	30.94	14.10	30.88	14.
35	31.97	14.24	31.91	14.38	31.85	14.51	31.78	14.
36	32.89	14.64	32.82	14.79	32.76	14.93	32.69	15.
37	33.80	15.05	33.74	15.20	33.67	15.34	33.60	15.
38	34.71	15.46	34.65	15.61	34.58	15.76	34.51	15.
39	35.63	15.86	35.56	16.02	35.49	16.17	35.42	16.
40	36.54	16.27	36.47	16.43	36.40	16.59	36.33	16.
41	37.46	16.68	37.38	16.84	37.31	17.00	37.23	17.
42	38.37	17.08	38.29	17.25	38.22	17.42	38.14	17.
43	39.28	17.49	39.21	17.66	39.13	17.83	39.05	18.
44	40.20	17.90	40.12	18.07	40.04	18.25	39.96	18.
45	41.11	18.30	41.03	18.48	40.95	18.66	40.87	18.
46	42.02	18.71	41.94	18.89	41.86	19.08	41.77	19.
47	42.94	19.12	42.85	19.30	42.77	19.49	42.68	19.
48	43.85	19.52	43.76	19.71	43.68	19.91	43.59	20.
49	44.76	19.93	44.68	20.13	44.59	20.32	44.50	20.
50	45.68	20.34	45.59	20.54	45.50	20.73	45.41	20.
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat
	66 Deg.		65¾ Deg.		65½ Deg.		65¼ Deg.	

Distance.	24 Deg.		24¼ Deg.		24½ Deg.		24¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	46.59	20.74	46.50	20.95	46.41	21.15	46.32	21.35	51
52	47.50	21.15	47.41	21.36	47.32	21.56	47.22	21.77	52
53	48.42	21.56	48.32	21.77	48.23	21.98	48.13	22.19	53
54	49.33	21.96	49.24	22.18	49.14	22.39	49.04	22.61	54
55	50.24	22.37	50.15	22.59	50.05	22.81	49.95	23.03	55
56	51.16	22.78	51.06	23.00	50.96	23.22	50.86	23.44	56
57	52.07	23.18	51.97	23.41	51.87	23.64	51.76	23.86	57
58	52.99	23.59	52.88	23.82	52.78	24.05	52.67	24.28	58
59	53.90	24.00	53.79	24.23	53.69	24.47	53.58	24.70	59
60	54.81	24.40	54.71	24.64	54.60	24.88	54.49	25.12	60
61	55.73	24.81	55.62	25.05	55.51	25.30	55.40	25.54	61
62	56.64	25.22	56.53	25.46	56.42	25.71	56.30	25.96	62
63	57.55	25.62	57.44	25.88	57.33	26.13	57.21	26.38	63
64	58.47	26.03	58.35	26.29	58.24	26.54	58.12	26.79	64
65	59.38	26.44	59.26	26.70	59.15	26.96	59.03	27.21	65
66	60.29	26.84	60.18	27.11	60.06	27.37	59.94	27.63	66
67	61.21	27.25	61.09	27.52	60.97	27.78	60.85	28.05	67
68	62.12	27.66	62.00	27.93	61.88	28.20	61.75	28.47	68
69	63.03	28.06	62.91	28.34	62.79	28.61	62.66	28.89	69
70	63.95	28.47	63.82	28.75	63.70	29.03	63.57	29.31	70
71	64.86	28.88	64.74	29.16	64.61	29.44	64.48	29.72	71
72	65.78	29.28	65.65	29.57	65.52	29.86	65.39	30.14	72
73	66.69	29.69	66.56	29.98	66.43	30.27	66.29	30.56	73
74	67.60	30.10	67.47	30.39	67.34	30.69	67.20	30.98	74
75	68.52	30.51	68.38	30.80	68.25	31.10	68.11	31.40	75
76	69.43	30.91	69.29	31.21	69.16	31.52	69.02	31.82	76
77	70.34	31.32	70.21	31.63	70.07	31.93	69.93	32.24	77
78	71.26	31.73	71.12	32.04	70.98	32.35	70.84	32.66	78
79	72.17	32.13	72.03	32.45	71.89	32.76	71.74	33.07	79
80	73.08	32.54	72.94	32.86	72.80	33.18	72.65	33.49	80
81	74.00	32.95	73.85	33.27	73.71	33.59	73.56	33.91	81
82	74.91	33.35	74.76	33.68	74.62	34.00	74.47	34.33	82
83	75.82	33.76	75.68	34.09	75.53	34.42	75.38	34.75	83
84	76.74	34.17	76.59	34.50	76.44	34.83	76.28	35.17	84
85	77.65	34.57	77.50	34.91	77.35	35.25	77.19	35.59	85
86	78.56	34.98	78.41	35.32	78.26	35.66	78.10	36.00	86
87	79.48	35.39	79.32	35.73	79.17	36.08	79.01	36.42	87
88	80.39	35.79	80.24	36.14	80.08	36.49	79.92	36.84	88
89	81.31	36.20	81.15	36.55	80.99	36.91	80.82	37.26	89
90	82.22	36.61	82.06	36.96	81.90	37.32	81.73	37.68	90
91	83.13	37.01	82.97	37.38	82.81	37.74	82.64	38.10	91
92	84.05	37.42	83.88	37.79	83.72	38.15	83.55	38.52	92
93	84.96	37.83	84.79	38.20	84.63	38.57	84.46	38.94	93
94	85.87	38.23	85.71	38.61	85.54	38.98	85.37	39.35	94
95	86.79	38.64	86.62	39.02	86.45	39.40	86.27	39.77	95
96	87.70	39.05	87.53	39.43	87.36	39.81	87.18	40.19	96
97	88.61	39.45	88.44	39.84	88.27	40.23	88.09	40.61	97
98	89.53	39.86	89.35	40.25	89.18	40.64	89.00	41.03	98
99	90.44	40.27	90.26	40.66	90.09	41.05	89.91	41.45	99
100	91.35	40.67	91.18	41.07	91.00	41.47	90.81	41.87	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	66 Deg.		65¾ Deg.		65½ Deg.		65¼ Deg.		

Distance.	25 Deg.		25¼ Deg.		25½ Deg.		25¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.91	0.42	0.90	0.43	0.90	0.43	0.90	0.43	1
2	1.81	0.85	1.81	0.85	1.81	0.86	1.80	0.87	2
3	2.72	1.27	2.71	1.28	2.71	1.29	2.70	1.30	3
4	3.63	1.69	3.62	1.71	3.61	1.72	3.60	1.74	4
5	4.53	2.11	4.52	2.13	4.51	2.15	4.50	2.17	5
6	5.44	2.54	5.43	2.56	5.42	2.58	5.40	2.61	6
7	6.34	2.96	6.33	2.99	6.32	3.01	6.30	3.04	7
8	7.25	3.38	7.24	3.41	7.22	3.44	7.21	3.48	8
9	8.16	3.80	8.14	3.84	8.12	3.87	8.11	3.91	9
10	9.06	4.23	9.04	4.27	9.03	4.31	9.01	4.34	10
11	9.97	4.65	9.95	4.69	9.93	4.74	9.91	4.78	11
12	10.88	5.07	10.85	5.12	10.83	5.17	10.81	5.21	12
13	11.78	5.49	11.76	5.55	11.73	5.60	11.71	5.65	13
14	12.69	5.92	12.66	5.97	12.64	6.03	12.61	6.08	14
15	13.59	6.34	13.57	6.40	13.54	6.46	13.51	6.52	15
16	14.50	6.76	14.47	6.83	14.44	6.89	14.41	6.95	16
17	15.41	7.18	15.38	7.25	15.34	7.32	15.31	7.39	17
18	16.31	7.61	16.28	7.68	16.25	7.75	16.21	7.82	18
19	17.22	8.03	17.18	8.10	17.15	8.18	17.11	8.25	19
20	18.13	8.45	18.09	8.53	18.05	8.61	18.01	8.69	20
21	19.03	8.87	18.99	8.96	18.95	9.04	18.91	9.12	21
22	19.94	9.30	19.90	9.38	19.86	9.47	19.82	9.56	22
23	20.85	9.72	20.80	9.81	20.76	9.90	20.72	9.99	23
24	21.75	10.14	21.71	10.24	21.66	10.33	21.62	10.43	24
25	22.66	10.57	22.61	10.66	22.56	10.76	22.52	10.86	25
26	23.56	10.99	23.52	11.09	23.47	11.19	23.42	11.30	26
27	24.47	11.41	24.42	11.52	24.37	11.62	24.32	11.73	27
28	25.38	11.83	25.32	11.94	25.27	12.05	25.22	12.16	28
29	26.28	12.26	26.23	12.37	26.17	12.48	26.12	12.60	29
30	27.19	12.68	27.13	12.80	27.08	12.92	27.02	13.03	30
31	28.10	13.10	28.04	13.22	27.98	13.35	27.92	13.47	31
32	29.00	13.52	28.94	13.65	28.88	13.78	28.82	13.90	32
33	29.91	13.95	29.85	14.08	29.79	14.21	29.72	14.34	33
34	30.81	14.37	30.75	14.50	30.69	14.64	30.62	14.77	34
35	31.72	14.79	31.66	14.93	31.59	15.07	31.52	15.21	35
36	32.63	15.21	32.56	15.36	32.49	15.50	32.43	15.64	36
37	33.53	15.64	33.46	15.78	33.40	15.93	33.33	16.07	37
38	34.44	16.06	34.37	16.21	34.30	16.36	34.23	16.51	38
39	35.35	16.48	35.27	16.64	35.20	16.79	35.13	16.94	39
40	36.25	16.90	36.18	17.06	36.10	17.22	36.03	17.38	40
41	37.16	17.33	37.08	17.49	37.01	17.65	36.93	17.81	41
42	38.06	17.75	37.99	17.92	37.91	18.08	37.83	18.25	42
43	38.97	18.17	38.89	18.34	38.81	18.51	38.73	18.68	43
44	39.88	18.60	39.80	18.77	39.71	18.94	39.63	19.12	44
45	40.78	19.02	40.70	19.20	40.62	19.37	40.53	19.55	45
46	41.69	19.44	41.60	19.62	41.52	19.80	41.43	19.98	46
47	42.60	19.86	42.51	20.05	42.42	20.23	42.33	20.42	47
48	43.50	20.29	43.41	20.48	43.32	20.66	43.23	20.85	48
49	44.41	20.71	44.32	20.90	44.23	21.10	44.13	21.29	49
50	45.32	21.13	45.22	21.33	45.13	21.53	45.03	21.72	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	65 Deg.		64¾ Deg.		64½ Deg.		64¼ Deg.		

Distance.	25 Deg.		25¼ Deg.		25½ Deg.		25¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	46.22	21.55	46.13	21.75	46.03	21.96	45.94	22.16	51
52	47.13	21.98	47.03	22.18	46.93	22.39	46.84	22.59	52
53	48.03	22.40	47.94	22.61	47.84	22.82	47.74	23.03	53
54	48.94	22.82	48.84	23.03	48.74	23.25	48.64	23.46	54
55	49.85	23.24	49.74	23.46	49.64	23.68	49.54	23.89	55
56	50.75	23.67	50.65	23.89	50.54	24.11	50.44	24.33	56
57	51.66	24.09	51.55	24.31	51.45	24.54	51.34	24.76	57
58	52.57	24.51	52.46	24.74	52.35	24.97	52.24	25.20	58
59	53.47	24.93	53.36	25.17	53.25	25.40	53.14	25.63	59
60	54.38	25.36	54.27	25.59	54.16	25.83	54.04	26.07	60
61	55.28	25.78	55.17	26.02	55.06	26.26	54.94	26.50	61
62	56.19	26.20	56.08	26.45	55.96	26.69	55.84	26.94	62
63	57.10	26.62	56.98	26.87	56.86	27.12	56.74	27.37	63
64	58.00	27.05	57.89	27.30	57.77	27.55	57.64	27.80	64
65	58.91	27.47	58.79	27.73	58.67	27.98	58.55	28.24	65
66	59.82	27.89	59.69	28.15	59.57	28.41	59.45	28.67	66
67	60.72	28.32	60.60	28.58	60.47	28.84	60.35	29.11	67
68	61.63	28.74	61.50	29.01	61.38	29.27	61.25	29.54	68
69	62.54	29.16	62.41	29.43	62.28	29.71	62.15	29.98	69
70	63.44	29.58	63.31	29.86	63.18	30.14	63.05	30.41	70
71	64.35	30.01	64.22	30.29	64.08	30.57	63.95	30.85	71
72	65.25	30.43	65.12	30.71	64.99	31.00	64.85	31.28	72
73	66.16	30.85	66.03	31.14	65.89	31.43	65.75	31.71	73
74	67.07	31.27	66.93	31.57	66.79	31.86	66.65	32.15	74
75	67.97	31.70	67.83	31.99	67.69	32.29	67.55	32.58	75
76	68.88	32.12	68.74	32.42	68.60	32.72	68.45	33.02	76
77	69.79	32.54	69.64	32.85	69.50	33.15	69.35	33.45	77
78	70.69	32.96	70.55	33.27	70.40	33.58	70.25	33.89	78
79	71.60	33.39	71.45	33.70	71.30	34.01	71.16	34.32	79
80	72.50	33.81	72.36	34.13	72.21	34.44	72.06	34.76	80
81	73.41	34.23	73.26	34.55	73.11	34.87	72.96	35.19	81
82	74.32	34.65	74.17	34.98	74.01	35.30	73.86	35.62	82
83	75.22	35.08	75.07	35.41	74.91	35.73	74.76	36.06	83
84	76.13	35.50	75.97	35.83	75.82	36.16	75.66	36.49	84
85	77.04	35.92	76.88	36.26	76.72	36.59	76.56	36.93	85
86	77.94	36.35	77.78	36.68	77.62	37.02	77.46	37.36	86
87	78.85	36.77	78.69	37.11	78.52	37.45	78.36	37.80	87
88	79.76	37.19	79.59	37.54	79.43	37.88	79.26	38.23	88
89	80.66	37.61	80.50	37.96	80.33	38.32	80.16	38.67	89
90	81.57	38.04	81.40	38.39	81.23	38.75	81.06	39.10	90
91	82.47	38.46	82.31	38.82	82.14	39.18	81.96	39.53	91
92	83.38	38.88	83.21	39.24	83.04	39.61	82.86	39.97	92
93	84.29	39.30	84.11	39.67	83.94	40.04	83.76	40.40	93
94	85.19	39.73	85.02	40.10	84.84	40.47	84.67	40.84	94
95	86.10	40.15	85.92	40.52	85.75	40.90	85.57	41.27	95
96	87.01	40.57	86.83	40.95	86.65	41.33	86.47	41.71	96
97	87.91	40.99	87.73	41.38	87.55	41.76	87.37	42.14	97
98	88.82	41.42	88.64	41.80	88.45	42.19	88.27	42.58	98
99	89.72	41.84	89.54	42.23	89.36	42.62	89.17	43.01	99
100	90.63	42.26	90.45	42.66	90.26	43.05	90.07	43.44	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	65 Deg.		64¾ Deg.		64½ Deg.		64¼ Deg.		

Distance.	26 Deg.		26¼ Deg.		26½ Deg.		26¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.90	0.44	0.90	0.44	0.89	0.45	0.89	0.45	1
2	1.80	0.88	1.79	0.88	1.79	0.89	1.79	0.90	2
3	2.70	1.32	2.69	1.33	2.68	1.34	2.68	1.35	3
4	3.60	1.75	3.59	1.77	3.58	1.78	3.57	1.80	4
5	4.49	2.19	4.48	2.21	4.47	2.23	4.46	2.25	5
6	5.39	2.63	5.38	2.65	5.37	2.68	5.36	2.70	6
7	6.29	3.07	6.28	3.10	6.26	3.12	6.25	3.15	7
8	7.19	3.51	7.17	3.54	7.16	3.57	7.14	3.60	8
9	8.09	3.95	8.07	3.98	8.05	4.02	8.04	4.05	9
10	8.99	4.38	8.97	4.42	8.95	4.46	8.93	4.50	10
11	9.89	4.82	9.87	4.87	9.84	4.91	9.82	4.95	11
12	10.79	5.26	10.76	5.31	10.74	5.35	10.72	5.40	12
13	11.68	5.70	11.66	5.75	11.63	5.80	11.61	5.85	13
14	12.58	6.14	12.56	6.19	12.53	6.25	12.50	6.30	14
15	13.48	6.58	13.45	6.63	13.42	6.69	13.39	6.75	15
16	14.38	7.01	14.35	7.08	14.32	7.14	14.29	7.20	16
17	15.28	7.45	15.25	7.52	15.21	7.59	15.18	7.65	17
18	16.18	7.89	16.14	7.96	16.11	8.03	16.07	8.10	18
19	17.08	8.33	17.04	8.40	17.00	8.48	16.97	8.55	19
20	17.98	8.77	17.94	8.85	17.90	8.92	17.86	9.00	20
21	18.87	9.21	18.83	9.29	18.79	9.37	18.75	9.45	21
22	19.77	9.64	19.73	9.73	19.69	9.82	19.65	9.90	22
23	20.67	10.08	20.63	10.17	20.58	10.26	20.54	10.35	23
24	21.57	10.52	21.52	10.61	21.48	10.71	21.43	10.80	24
25	22.47	10.96	22.42	11.06	22.37	11.15	22.32	11.25	25
26	23.37	11.40	23.32	11.50	23.27	11.60	23.22	11.70	26
27	24.27	11.84	24.22	11.94	24.16	12.05	24.11	12.15	27
28	25.17	12.27	25.11	12.38	25.06	12.49	25.00	12.60	28
29	26.06	12.71	26.01	12.83	25.95	12.94	25.90	13.05	29
30	26.96	13.15	26.91	13.27	26.85	13.39	26.79	13.50	30
31	27.86	13.59	27.80	13.71	27.74	13.83	27.68	13.95	31
32	28.76	14.03	28.70	14.15	28.64	14.28	28.58	14.40	32
33	29.66	14.47	29.60	14.60	29.53	14.72	29.47	14.85	33
34	30.56	14.90	30.49	15.04	30.43	15.17	30.36	15.30	34
35	31.46	15.34	31.39	15.48	31.32	15.62	31.25	15.75	35
36	32.36	15.78	32.29	15.92	32.22	16.06	32.15	16.20	36
37	33.26	16.22	33.18	16.36	33.11	16.51	33.04	16.65	37
38	34.15	16.66	34.08	16.81	34.01	16.96	33.93	17.10	38
39	35.05	17.10	34.98	17.25	34.90	17.40	34.83	17.55	39
40	35.95	17.53	35.87	17.69	35.80	17.85	35.72	18.00	40
41	36.85	17.97	36.77	18.13	36.69	18.29	36.61	18.45	41
42	37.75	18.41	37.67	18.58	37.59	18.74	37.51	18.90	42
43	38.65	18.85	38.57	19.02	38.48	19.19	38.40	19.35	43
44	39.55	19.29	39.46	19.46	39.38	19.63	39.29	19.80	44
45	40.45	19.73	40.36	19.90	40.27	20.08	40.18	20.25	45
46	41.34	20.17	41.26	20.35	41.17	20.53	41.08	20.70	46
47	42.24	20.60	42.15	20.79	42.06	20.97	41.97	21.15	47
48	43.14	21.04	43.05	21.23	42.96	21.42	42.86	21.60	48
49	44.04	21.48	43.95	21.67	43.85	21.86	43.76	22.05	49
50	44.94	21.92	44.84	22.11	44.75	22.31	44.65	22.50	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	64 Deg.		63¾ Deg.		63½ Deg.		63¼ Deg.		

Distance.	26 Deg.		26¼ Deg.		26½ Deg.		26¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	45.84	22.36	45.74	22.56	45.64	22.76	45.54	22.96	51
52	46.74	22.80	46.64	23.00	46.54	23.20	46.43	23.41	52
53	47.64	23.23	47.53	23.44	47.43	23.65	47.33	23.86	53
54	48.53	23.67	48.43	23.88	48.33	24.09	48.22	24.31	54
55	49.43	24.11	49.33	24.33	49.22	24.54	49.11	24.76	55
56	50.33	24.55	50.22	24.77	50.12	24.99	50.01	25.21	56
57	51.23	24.99	51.12	25.21	51.01	25.43	50.90	25.66	57
58	52.13	25.43	52.02	25.65	51.91	25.88	51.79	26.11	58
59	53.03	25.86	52.92	26.09	52.80	26.33	52.69	26.56	59
60	53.93	26.30	53.81	26.54	53.70	26.77	53.58	27.01	60
61	54.83	26.74	54.71	26.98	54.59	27.22	54.47	27.46	61
62	55.73	27.18	55.61	27.42	55.49	27.66	55.36	27.91	62
63	56.62	27.62	56.50	27.86	56.38	28.11	56.26	28.36	63
64	57.52	28.06	57.40	28.31	57.28	28.56	57.15	28.81	64
65	58.42	28.49	58.30	28.75	58.17	29.00	58.04	29.26	65
66	59.32	28.93	59.19	29.19	59.07	29.45	58.94	29.71	66
67	60.22	29.37	60.09	29.63	59.96	29.90	59.83	30.16	67
68	61.12	29.81	60.99	30.08	60.86	30.34	60.72	30.61	68
69	62.02	30.25	61.88	30.52	61.75	30.79	61.62	31.06	69
70	62.92	30.69	62.78	30.96	62.65	31.23	62.51	31.51	70
71	63.81	31.12	63.68	31.40	63.54	31.68	63.40	31.96	71
72	64.71	31.56	64.57	31.84	64.44	32.13	64.29	32.41	72
73	65.61	32.00	65.47	32.29	65.33	32.57	65.19	32.86	73
74	66.51	32.44	66.37	32.73	66.23	33.02	66.08	33.31	74
75	67.41	32.88	67.27	33.17	67.12	33.46	66.97	33.76	75
76	68.31	33.32	68.16	33.61	68.01	33.91	67.87	34.21	76
77	69.21	33.75	69.06	34.06	68.91	34.36	68.76	34.66	77
78	70.11	34.19	69.96	34.50	69.80	34.80	69.65	35.11	78
79	71.00	34.63	70.85	34.94	70.70	35.25	70.55	35.56	79
80	71.90	35.07	71.75	35.38	71.59	35.70	71.44	36.01	80
81	72.80	35.51	72.65	35.83	72.49	36.14	72.33	36.46	81
82	73.70	35.95	73.54	36.27	73.38	36.59	73.22	36.91	82
83	74.60	36.38	74.44	36.71	74.28	37.03	74.12	37.36	83
84	75.50	36.82	75.34	37.15	75.17	37.48	75.01	37.81	84
85	76.40	37.26	76.23	37.59	76.07	37.93	75.90	38.26	85
86	77.30	37.70	77.13	38.04	76.96	38.37	76.80	38.71	86
87	78.20	38.14	78.03	38.48	77.86	38.82	77.69	39.16	87
88	79.09	38.58	78.92	38.92	78.75	39.27	78.58	39.61	88
89	79.99	39.01	79.82	39.36	79.65	39.71	79.48	40.06	89
90	80.89	39.45	80.72	39.81	80.54	40.16	80.37	40.51	90
91	81.79	39.89	81.62	40.25	81.44	40.60	81.26	40.96	91
92	82.69	40.33	82.51	40.69	82.33	41.05	82.15	41.41	92
93	83.59	40.77	83.41	41.13	83.23	41.50	83.05	41.86	93
94	84.49	41.21	84.31	41.58	84.12	41.94	83.94	42.31	94
95	85.39	41.65	85.20	42.02	85.02	42.39	84.83	42.76	95
96	86.28	42.08	86.10	42.46	85.91	42.83	85.73	43.21	96
97	87.18	42.52	87.00	42.90	86.81	43.28	86.62	43.66	97
98	88.08	42.96	87.89	43.34	87.70	43.73	87.51	44.11	98
99	88.98	43.40	88.79	43.79	88.60	44.17	88.40	44.56	99
100	89.88	43.84	89.69	44.23	89.49	44.62	89.30	45.01	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	64 Deg.		63¾ Deg.		63½ Deg.		63¼ Deg.		

Distance.	27 Deg.		27¼ Deg.		27½ Deg.		27¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.89	0.45	0.89	0.46	0.89	0.46	0.88	0.47	1
2	1.78	0.91	1.78	0.92	1.77	0.92	1.77	0.93	2
3	2.67	1.36	2.67	1.37	2.66	1.39	2.65	1.40	3
4	3.56	1.82	3.56	1.83	3.55	1.85	3.54	1.86	4
5	4.45	2.27	4.45	2.29	4.44	2.31	4.42	2.33	5
6	5.35	2.72	5.33	2.75	5.32	2.77	5.31	2.79	6
7	6.24	3.18	6.22	3.21	6.21	3.23	6.19	3.26	7
8	7.13	3.63	7.11	3.66	7.10	3.69	7.08	3.72	8
9	8.02	4.09	8.00	4.12	7.98	4.16	7.96	4.19	9
10	8.91	4.54	8.89	4.58	8.87	4.62	8.85	4.66	10
11	9.80	4.99	9.78	5.04	9.76	5.08	9.73	5.12	11
12	10.69	5.45	10.67	5.49	10.64	5.54	10.62	5.59	12
13	11.58	5.90	11.56	5.95	11.53	6.00	11.50	6.05	13
14	12.47	6.36	12.45	6.41	12.42	6.46	12.39	6.52	14
15	13.37	6.81	13.34	6.87	13.31	6.93	13.27	6.98	15
16	14.26	7.26	14.22	7.33	14.19	7.39	14.16	7.45	16
17	15.15	7.72	15.11	7.78	15.08	7.85	15.04	7.92	17
18	16.04	8.17	16.00	8.24	15.97	8.31	15.93	8.38	18
19	16.93	8.63	16.89	8.70	16.85	8.77	16.81	8.85	19
20	17.82	9.08	17.78	9.16	17.74	9.23	17.70	9.31	20
21	18.71	9.53	18.67	9.62	18.63	9.70	18.58	9.78	21
22	19.60	9.99	19.56	10.07	19.51	10.16	19.47	10.24	22
23	20.49	10.44	20.45	10.53	20.40	10.62	20.35	10.71	23
24	21.38	10.90	21.34	10.99	21.29	11.08	21.24	11.17	24
25	22.28	11.35	22.23	11.45	22.18	11.54	22.12	11.64	25
26	23.17	11.80	23.11	11.90	23.06	12.01	23.01	12.11	26
27	24.06	12.26	24.00	12.36	23.95	12.47	23.89	12.57	27
28	24.95	12.71	24.89	12.82	24.84	12.93	24.78	13.04	28
29	25.84	13.17	25.78	13.28	25.72	13.39	25.66	13.50	29
30	26.73	13.62	26.67	13.74	26.61	13.85	26.55	13.97	30
31	27.62	14.07	27.56	14.19	27.50	14.31	27.43	14.43	31
32	28.51	14.53	28.45	14.65	28.38	14.78	28.32	14.90	32
33	29.40	14.98	29.34	15.11	29.27	15.24	29.20	15.37	33
34	30.29	15.44	30.23	15.57	30.16	15.70	30.09	15.83	34
35	31.19	15.89	31.12	16.03	31.05	16.16	30.97	16.30	35
36	32.08	16.34	32.00	16.48	31.93	16.62	31.86	16.76	36
37	32.97	16.80	32.89	16.94	32.82	17.08	32.74	17.23	37
38	33.86	17.25	33.78	17.40	33.71	17.55	33.63	17.69	38
39	34.75	17.71	34.67	17.86	34.59	18.01	34.51	18.16	39
40	35.64	18.16	35.56	18.31	35.48	18.47	35.40	18.62	40
41	36.53	18.61	36.45	18.77	36.37	18.93	36.28	19.09	41
42	37.42	19.07	37.34	19.23	37.25	19.39	37.17	19.56	42
43	38.31	19.52	38.23	19.69	38.14	19.86	38.05	20.02	43
44	39.20	19.98	39.12	20.15	39.03	20.32	38.94	20.49	44
45	40.10	20.43	40.01	20.60	39.92	20.78	39.82	20.95	45
46	40.99	20.88	40.89	21.06	40.80	21.24	40.71	21.42	46
47	41.88	21.34	41.78	21.52	41.69	21.70	41.59	21.88	47
48	42.77	21.79	42.67	21.98	42.58	22.16	42.48	22.35	48
49	43.66	22.25	43.56	22.44	43.46	22.63	43.36	22.82	49
50	44.55	22.70	44.45	22.89	44.35	23.09	44.25	23.28	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	63 Deg.		62¾ Deg.		62½ Deg.		62¼ Deg.		

Distance.	27 Deg.		27¼ Deg.		27½ Deg.		27¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	45.44	23.15	45.34	23.35	45.24	23.55	45.13	23.75	51
52	46.33	23.61	46.23	23.81	46.12	24.01	46.02	24.21	52
53	47.22	24.06	47.12	24.27	47.01	24.47	46.90	24.68	53
54	48.11	24.52	48.01	24.73	47.90	24.93	47.79	25.14	54
55	49.01	24.97	48.90	25.18	48.79	25.40	48.67	25.61	55
56	49.90	25.42	49.78	25.64	49.67	25.86	49.56	26.07	56
57	50.79	25.88	50.67	26.10	50.56	26.32	50.44	26.54	57
58	51.68	26.33	51.56	26.56	51.45	26.78	51.33	27.01	58
59	52.57	26.79	52.45	27.01	52.33	27.24	52.21	27.47	59
60	53.46	27.24	53.34	27.47	53.22	27.70	53.10	27.94	60
61	54.35	27.69	54.23	27.93	54.11	28.17	53.98	28.40	61
62	55.24	28.15	55.12	28.39	54.99	28.63	54.87	28.87	62
63	56.13	28.60	56.01	28.85	55.88	29.09	55.75	29.33	63
64	57.02	29.06	56.90	29.30	56.77	29.55	56.64	29.80	64
65	57.92	29.51	57.79	29.76	57.66	30.01	57.52	30.26	65
66	58.81	29.96	58.68	30.22	58.54	30.48	58.41	30.73	66
67	59.70	30.42	59.56	30.68	59.43	30.94	59.29	31.20	67
68	60.59	30.87	60.45	31.14	60.32	31.40	60.18	31.66	68
69	61.48	31.33	61.34	31.59	61.20	31.86	61.06	32.13	69
70	62.37	31.78	62.23	32.05	62.09	32.32	61.95	32.59	70
71	63.26	32.23	63.12	32.51	62.98	32.78	62.83	33.06	71
72	64.15	32.69	64.01	32.97	63.86	33.25	63.72	33.52	72
73	65.04	33.14	64.90	33.42	64.75	33.71	64.60	33.99	73
74	65.93	33.60	65.79	33.88	65.64	34.17	65.49	34.46	74
75	66 83	34.05	66.68	34.34	66.53	34.63	66.37	34.92	75
76	67.72	34.50	67.57	34.80	67.41	35.09	67.26	35.39	76
77	68.61	34.96	68.45	35.26	68.30	35.55	68.14	35.85	77
78	69.50	35.41	69.34	35.71	69.19	36.02	69.03	36.32	78
79	70.39	35.87	70.23	36.17	70.07	36.48	69.91	36.78	79
80	71.28	36.32	71.12	36.63	70.96	36.94	70.80	37.25	80
81	72.17	36.77	72.01	37.09	71.85	37.40	71.68	37.71	81
82	73.06	37.23	72.90	37.55	72.73	37.86	72.57	38.18	82
83	73.95	37.68	73.79	38.00	73.62	38.33	73.45	38.65	83
84	74.84	38.14	74.68	38.46	74.51	38.79	74.34	39.11	84
85	75.74	38.59	75.57	38.92	75.40	39.25	75.22	39.58	85
86	76.63	39.04	76.46	39.38	76.28	39.71	76.11	40.04	86
87	77.52	39.50	77.34	39.83	77.17	40.17	76.99	40.51	87
88	78.41	39.95	78.23	40.29	78.06	40.63	77.88	40.97	88
89	79.30	40.41	79.12	40.75	78.94	41.10	78.76	41.44	89
90	80.19	40.86	80.01	41.21	79.83	41.56	79.65	41.91	90
91	81.08	41.31	80.90	41.67	80.72	42.02	80.53	42.37	91
92	81.97	41.77	81.79	42.12	81.60	42.48	81.42	42.84	92
93	82.86	42.22	82.68	42.58	82.49	42.94	82.30	43.30	93
94	83.75	42.68	83.57	43.04	83.38	43.40	83.19	43.77	94
95	84.65	43.13	84.46	43.50	84.27	43.87	84.07	44.23	95
96	85.54	43.58	85.35	43.96	85.15	44.33	84.96	44.70	96
97	86.43	44.04	86.23	44.41	86.04	44.79	85.84	45.16	97
98	87.32	44.49	87.12	44.87	86.93	45.25	86.73	45.63	98
99	88.21	44.95	88.01	45.33	87.81	45.71	87.61	46.10	99
100	89.10	45.40	88.90	45.79	88.70	46.17	88.50	46.56	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	63 Deg.		62¾ Deg.		62½ Deg.		62¼ Deg.		

Distance.	28 Deg.		28¼ Deg.		28½ Deg.		28¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.88	0.47	0.88	0.47	0.88	0.48	0.88	0.48	1
2	1.77	0.94	1.76	0.95	1.76	0.95	1.75	0.96	2
3	2.65	1.41	2.64	1.42	2.64	1.43	2.63	1.44	3
4	3.53	1.88	3.52	1.89	3.52	1.91	3.51	1.92	4
5	4.41	2.35	4.40	2.37	4.39	2.39	4.38	2.40	5
6	5.30	2.82	5.29	2.84	5.27	2.86	5.26	2.89	6
7	6.18	3.29	6.17	3.31	6.15	3.34	6.14	3.37	7
8	7.06	3.76	7.05	3.79	7.03	3.82	7.01	3.85	8
9	7.95	4.23	7.93	4.26	7.91	4.29	7.89	4.33	9
10	8.83	4.69	8.81	4.73	8.79	4.77	8.77	4.81	10
11	9.71	5.16	9.69	5.21	9.67	5.25	9.64	5.29	11
12	10.60	5.63	10.57	5.68	10.55	5.73	10.52	5.77	12
13	11.48	6.10	11.45	6.15	11.42	6.20	11.40	6.25	13
14	12.36	6.57	12.33	6.63	12.30	6.68	12.27	6.73	14
15	13.24	7.04	13.21	7.10	13.18	7.16	13.15	7.21	15
16	14.13	7.51	14.09	7.57	14.06	7.63	14.03	7.70	16
17	15.01	7.98	14.98	8.05	14.94	8.11	14.90	8.18	17
18	15.89	8.45	15.86	8.52	15.82	8.59	15.78	8.66	18
19	16.78	8.92	16.74	8.99	16.70	9.07	16.66	9.14	19
20	17.66	9.39	17.62	9.47	17.58	9.54	17.53	9.62	20
21	18.54	9.86	18.50	9.94	18.46	10.02	18.41	10.10	21
22	19.42	10.33	19.38	10.41	19.33	10.50	19.29	10.58	22
23	20.31	10.80	20.26	10.89	20.21	10.97	20.16	11.06	23
24	21.19	11.27	21.14	11.36	21.09	11.45	21.04	11.54	24
25	22.07	11.74	22.02	11.83	21.97	11.93	21.92	12.02	25
26	22.96	12.21	22.90	12.31	22.85	12.41	22.79	12.51	26
27	23.84	12.68	23.78	12.78	23.73	12.88	23.67	12.99	27
28	24.72	13.15	24.66	13.25	24.61	13.36	24.55	13.47	28
29	25.61	13.61	25.55	13.73	25.49	13.84	25.43	13.95	29
30	26.49	14.08	26.43	14.20	26.36	14.31	26.30	14.43	30
31	27.37	14.55	27.31	14.67	27.24	14.79	27.18	14.91	31
32	28.25	15.02	28.19	15.15	28.12	15.27	28.06	15.39	32
33	29.14	15.49	29.07	15.62	29.00	15.75	28.93	15.87	33
34	30.02	15.96	29.95	16.09	29.88	16.22	29.81	16.35	34
35	30.90	16.43	30.83	16.57	30.76	16.70	30.69	16.83	35
36	31.79	16.90	31.71	17.04	31.64	17.18	31.56	17.32	36
37	32.67	17.37	32.59	17.51	32.52	17.65	32.44	17.80	37
38	33.55	17.84	33.47	17.99	33.39	18.13	33.32	18.28	38
39	34.43	18.31	34.35	18.46	34.27	18.61	34.19	18.76	39
40	35.32	18.78	35.24	18.93	35.15	19.09	35.07	19.24	40
41	36.20	19.25	36.12	19.41	36.03	19.56	35.95	19.72	41
42	37.08	19.72	37.00	19.88	36.91	20.04	36.82	20.20	42
43	37.97	20.19	37.88	20.35	37.79	20.52	37.70	20.68	43
44	38.85	20.66	38.76	20.83	38.67	20.99	38.58	21.16	44
45	39.73	21.13	39.64	21.30	39.55	21.47	39.45	21.64	45
46	40.62	21.60	40.52	21.77	40.43	21.95	40.33	22.13	46
47	41.50	22.07	41.40	22.25	41.30	22.43	41.21	22.61	47
48	42.38	22.53	42.28	22.72	42.18	22.90	42.08	23.09	48
49	43.26	23.00	43.16	23.19	43.06	23.38	42.96	23.57	49
50	44.15	23.47	44.04	23.67	43.94	23.86	43.84	24.05	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	62 Deg.		61¾ Deg.		61½ Deg.		61¼ Deg.		

Distance.	28 Deg.		28¼ Deg.		28½ Deg.		28¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	45.03	23.94	44.93	24.14	44.82	24.34	44.71	24.53	51
52	45.91	24.41	45.81	24.61	45.70	24.81	45.59	25.01	52
53	46.80	24.88	46.69	25.09	46.58	25.29	46.47	25.49	53
54	47.68	25.35	47.57	25.56	47.46	25.77	47.34	25.97	54
55	48.56	25.82	48.45	26.03	48.33	26.24	48.22	26.45	55
56	49.45	26.29	49.33	26.51	49.21	26.72	49.10	26.94	56
57	50.33	26.76	50.21	26.98	50.09	27.20	49.97	27.42	57
58	51.21	27.23	51.09	27.45	50.97	27.68	50.85	27.90	58
59	52.09	27.70	51.97	27.93	51.85	28.15	51.73	28.38	59
60	52.98	28.17	52.85	28.40	52.73	28.63	52.60	28.86	60
61	53.86	28.64	53.73	28.87	53.61	29.11	53.48	29.34	61
62	54.74	29.11	54.62	29.35	54.49	29.58	54.36	29.82	62
63	55.63	29.58	55.50	29.82	55.37	30.06	55.23	30.30	63
64	56.51	30.05	56.38	30.29	56.24	30.54	56.11	30.78	64
65	57.39	30.52	57.26	30.77	57.12	31.02	56.99	31.26	65
66	58.27	30.99	58.14	31.24	58.00	31.49	57.86	31.75	66
67	59.16	31.45	59.02	31.71	58.88	31.97	58.74	32.23	67
68	60.04	31.92	59.90	32.19	59.76	32.45	59.62	32.71	68
69	60.92	32.39	60.78	32.66	60.64	32.92	60.49	33.19	69
70	61.81	32.86	61.66	33.13	61.52	33.40	61.37	33.67	70
71	62.69	33.33	62.54	33.61	62.40	33.88	62.25	34.15	71
72	63.57	33.80	63.42	34.08	63.27	34.36	63.12	34.63	72
73	64.46	34.27	64.30	34.55	64.15	34.83	64.00	35.11	73
74	65.34	34.74	65.19	35.03	65.03	35.31	64.88	35.59	74
75	66.22	35.21	66.07	35.50	65.91	35.79	65.75	36.07	75
76	67.10	35.68	66.95	35.97	66.79	36.26	66.63	36.56	76
77	67.99	36.15	67.83	36.45	67.67	36.74	67.51	37.04	77
78	68.87	36.62	68.71	36.92	68.55	37.22	68.38	37.52	78
79	69.75	37.09	69.59	37.39	69.43	37.70	69.26	38.00	79
80	70.64	37.56	70.47	37.87	70.31	38.17	70.14	38.48	80
81	71.52	38.03	71.35	38.34	71.18	38.65	71.01	38.96	81
82	72.40	38.50	72.23	38.81	72.06	39.13	71.89	39.44	82
83	73.28	38.97	73.11	39.29	72.94	39.60	72.77	39.92	83
84	74.17	39.44	73.99	39.76	73.82	40.08	73.64	40.40	84
85	75.05	39.91	74.88	40.23	74.70	40.56	74.52	40.88	85
86	75.93	40.37	75.76	40.71	75.58	41.04	75.40	41.36	86
87	76.82	40.84	76.64	41.18	76.46	41.51	76.28	41.85	87
88	77.70	41.31	77.52	41.65	77.34	41.99	77.15	42.33	88
89	78.58	41.78	78.40	42.13	78.21	42.47	78.03	42.81	89
90	79.47	42.25	79.28	42.60	79.09	42.94	78.91	43.29	90
91	80.35	42.72	80.16	43.07	79.97	43.42	79.78	43.77	91
92	81.23	43.19	81.04	43.55	80.85	43.90	80.66	44.25	92
93	82.11	43.66	81.92	44.02	81.73	44.38	81.54	44.73	93
94	83.00	44.13	82.80	44.49	82.61	44.85	82.41	45.21	94
95	83.88	44.60	83.68	44.97	83.49	45.33	83.29	45.69	95
96	84.76	45.07	84.57	45.44	84.37	45.81	84.17	46.17	96
97	85.65	45.54	85.45	45.91	85.25	46.28	85.04	46.66	97
98	86.53	46.01	86.33	46.39	86.12	46.76	85.92	47.14	98
99	87.41	46.48	87.21	46.86	87.00	47.24	86.80	47.62	99
100	88.29	46.95	88.09	47.33	87.88	47.72	87.67	48.10	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	62 Deg.		61¾ Deg.		61½ Deg.		61¼ Deg.		

Distance.	29 Deg.		29¼ Deg.		29½ Deg.		29¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.87	0.48	0.87	0.49	0.87	0.49	0.87	0.50	1
2	1.75	0.97	1.74	0.98	1.74	0.98	1.74	0.99	2
3	2.62	1.45	2.62	1.47	2.61	1.48	2.60	1.49	3
4	3.50	1.94	3.49	1.95	3.48	1.97	3.47	1.98	4
5	4.37	2.42	4.36	2.44	4.35	2.46	4.34	2.48	5
6	5.25	2.91	5.23	2.93	5.22	2.95	5.21	2.98	6
7	6.12	3.39	6.11	3.42	6.09	3.45	6.08	3.47	7
8	7.00	3.88	6.98	3.91	6.96	3.94	6.95	3.97	8
9	7.87	4.36	7.85	4.40	7.83	4.43	7.81	4.47	9
10	8.75	4.85	8.72	4.89	8.70	4.92	8.68	4.96	10
11	9.62	5.33	9.60	5.37	9.57	5.42	9.55	5.46	11
12	10.50	5.82	10.47	5.86	10.44	5.91	10.42	5.95	12
13	11.37	6.30	11.34	6.35	11.31	6.40	11.29	6.45	13
14	12.24	6.79	12.21	6.84	12.18	6.89	12.15	6.95	14
15	13.12	7.27	13.09	7.33	13.06	7.39	13.02	7.44	15
16	13.99	7.76	13.96	7.82	13.93	7.88	13.29	7.94	16
17	14.87	8.24	14.83	8.31	14.80	8.37	14.76	8.44	17
18	15.74	8.73	15.70	8.80	15.67	8.86	15.63	8.93	18
19	16.62	9.21	16.58	9.28	16.54	9.36	16.50	9.43	19
20	17.49	9.70	17.45	9.77	17.41	9.85	17.36	9.92	20
21	18.37	10.18	18.32	10.26	18.28	10.34	18.23	10.42	21
22	19.24	10.67	19.19	10.75	19.15	10.83	19.10	10.92	22
23	20.12	11.15	20.07	11.24	20.02	11.33	19.97	11.41	23
24	20.99	11.64	20.94	11.73	20.89	11.82	20.84	11.91	24
25	21.87	12.12	21.81	12.22	21.76	12.31	21.70	12.41	25
26	22.74	12.60	22.68	12.70	22.63	12.80	22.57	12.90	26
27	23.61	13.09	23.56	13.19	23.50	13.30	23.44	13.40	27
28	24.49	13.57	24.43	13.68	24.37	13.79	24.31	13.89	28
29	25.36	14.06	25.30	14.17	25.24	14.28	25.18	14.39	29
30	26.24	14.54	26.17	14.66	26.11	14.77	26.05	14.89	30
31	27.11	15.03	27.05	15.15	26.98	15.27	26.91	15.38	31
32	27.99	15.51	27.92	15.64	27.85	15.76	27.78	15.88	32
33	28.86	16.00	28.79	16.12	28.72	16.25	28.65	16.38	33
34	29.74	16.48	29.66	16.61	29.59	16.74	29.52	16.87	34
35	30.61	16.97	30.54	17.10	30.46	17.23	30.39	17.37	35
36	31.49	17.45	31.41	17.59	31.33	17.73	31.26	17.86	36
37	32.36	17.94	32.28	18.08	32.20	18.22	32.12	18.36	37
38	33.24	18.42	33.15	18.57	33.07	18.71	32.99	18.86	38
39	34.11	18.91	34.03	19.66	33.94	19.20	33.86	19.35	39
40	34.98	19.39	34.90	19.54	34.81	19.70	34.73	19.85	40
41	35.86	19.88	35.77	20.03	35.68	20.19	35.60	20.34	41
42	36.73	20.36	36.64	20.52	36.55	20.68	36.46	20.84	42
43	37.61	20.85	37.52	21.01	37.43	21.17	37.33	21.34	43
44	38.48	21.33	38.39	21.50	38.30	21.67	38.20	21.83	44
45	39.36	21.82	39.26	21.99	39.17	22.16	39.07	22.33	45
46	40.23	22.30	40.13	22.48	40.04	22.65	39.94	22.83	46
47	41.11	22.79	41.01	22.97	40.91	23.14	40.81	23.32	47
48	41.98	23.27	41.88	23.45	41.78	23.63	41.67	23.82	48
49	42.86	23.76	42.75	23.94	42.65	24.13	42.54	24.31	49
50	43.73	24.24	43.62	24.43	43.52	24.62	43.41	24.81	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	61 Deg.		60¾ Deg.		60½ Deg.		60¼ Deg.		

Distance.	29 Deg.		29¼ Deg.		29½ Deg.		29¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	44.61	24.73	44.50	24.92	44.39	25.11	44.28	25.31	51
52	45.48	25.21	45.37	25.41	45.26	25.61	45.15	25.80	52
53	46.35	25.69	46.24	25.90	46.13	26.10	46.01	26.30	53
54	47.23	26.18	47.11	26.39	47.00	26.59	46.88	26.80	54
55	48.10	26.66	47.99	26.87	47.87	27.08	47.75	27.29	55
56	48.98	27.15	48.86	27.36	48.74	27.58	48.62	27.79	56
57	49.85	27.63	49.73	27.85	49.61	28.07	49.49	28.28	57
58	50.73	28.12	50.60	28.34	50.48	28.56	50.36	28.78	58
59	51.60	28.60	51.48	28.83	51.35	29.05	51.22	29.28	59
60	52.48	29.09	52.35	29.32	52.22	29.55	52.09	29.77	60
61	53.35	29.57	53.22	29.81	53.09	30.04	52.96	30.27	61
62	54.23	30.06	54.09	30.29	53.96	30.53	53.83	30.77	62
63	55.10	30.54	54.97	30.78	54.83	31.02	54.70	31.26	63
64	55.98	31.03	55.84	31.27	55.70	31.52	55.56	31.76	64
65	56.85	31.51	56.71	31.76	56.57	32.01	56.43	32.25	65
66	57.72	32.00	57.58	32.25	57.44	32.50	57.30	32.75	66
67	58.60	32.48	58.46	32.74	58.31	32.99	58.17	33.25	67
68	59.47	32.97	59.33	33.23	59.18	33.48	59.04	33.74	68
69	60.35	33.45	60.20	33.71	60.05	33.98	59.91	34.24	69
70	61.22	33.94	61.07	34.20	60.92	34.47	60.77	34.74	70
71	62.10	34.42	61.95	34.69	61.80	34.96	61.64	35.23	71
72	62.97	34.91	62.82	35.18	62.67	35.45	62.51	35.73	72
73	63.85	35.39	63.69	35.67	63.54	35.95	63.38	36.22	73
74	64.72	35.88	64.56	36.16	64.41	36.44	64.25	36.72	74
75	65.60	36.36	65.44	36.65	65.28	36.93	65.11	37.22	75
76	66.47	36.85	66.31	37.14	66.15	37.42	65.98	37.71	76
77	67.35	37.33	67.18	37.62	67.02	37.92	66.85	38.21	77
78	68.22	37.82	68.05	38.11	67.89	38.41	67.72	38.70	78
79	69.09	38.30	68.93	38.60	68.76	38.90	68.59	39.20	79
80	69.97	38.78	69.80	39.09	69.63	39.39	69.46	39.70	80
81	70.84	39.27	70.67	39.58	70.50	39.89	70.32	40.19	81
82	71.72	39.75	71.54	40.07	71.37	40.38	71.19	40.69	82
83	72.59	40.24	72.42	40.56	72.24	40.87	72.06	41.19	83
84	73.47	40.72	73.29	41.04	73.11	41.36	72.93	41.68	84
85	74.34	41.21	74.16	41.53	73.98	41.86	73.80	42.18	85
86	75.22	41.69	75.03	42.02	74.85	42.35	74.67	42.67	86
87	76.09	42.18	75.91	42.51	75.72	42.84	75.53	43.17	87
88	76.97	42.66	76.78	43.00	76.59	43.33	76.40	43.67	88
89	77.84	43.15	77.65	43.49	77.46	43.83	77.27	44.16	89
90	78.72	43.63	78.52	43.98	78.33	44.32	78.14	44.66	90
91	79.59	44.12	79.40	44.46	79.20	44.81	79.01	45.16	91
92	80.46	44.60	80.27	44.95	80.07	45.30	79.87	45.65	92
93	81.34	45.09	81.14	45.44	80.94	45.80	80.74	46.15	93
94	82.21	45.57	82.01	45.93	81.81	46.29	81.61	46.64	94
95	83.09	46.06	82.89	46.42	82.68	46.78	82.48	47.14	95
96	83.96	46.54	83.76	46.91	83.55	47.27	83.35	47.64	96
97	84.84	47.03	84.63	47.40	84.42	47.77	84.22	48.13	97
98	85.71	47.51	85.50	47.88	85.29	48.26	85.08	48.63	98
99	86.59	48.00	86.38	48.37	86.17	48.75	85.95	49.13	99
100	87.46	48.48	87.25	48.86	87.04	49.24	86.82	49.62	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	61 Deg.		60¾ Deg.		60½ Deg.		60¼ Deg.		

Distance.	30 Deg.		30¼ Deg.		30½ Deg.		30¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.87	0.50	0.86	0.50	0.86	0.51	0.86	0.51	1
2	1.73	1.00	1.73	1.01	1.72	1.02	1.72	1.02	2
3	2.60	1.50	2.59	1.51	2.58	1.52	2.58	1.53	3
4	3.46	2.00	3.46	2.02	3.45	2.03	3.44	2.05	4
5	4.33	2.50	4.32	2.52	4.31	2.54	4.30	2.56	5
6	5.20	3.00	5.18	3.02	5.17	3.05	5.16	3.07	6
7	6.06	3.50	6.05	3.53	6.03	3.55	6.02	3.58	7
8	6.93	4.00	6.91	4.03	6.89	4.06	6.88	4.09	8
9	7.79	4.50	7.77	4.53	7.75	4.57	7.73	4.60	9
10	8.66	5.00	8.64	5.04	8.62	5.08	8.59	5.11	10
11	9.53	5.50	9.50	5.54	9.48	5.58	9.45	5.62	11
12	10.39	6.00	10.37	6.05	10.34	6.09	10.31	6.14	12
13	11.26	6.50	11.23	6.55	11.20	6.60	11.17	6.65	13
14	12.12	7.00	12.09	7.05	12.06	7.11	12.03	7.16	14
15	12.99	7.50	12.96	7.56	12.92	7.61	12.89	7.67	15
16	13.86	8.00	13.82	8.06	13.79	8.12	13.75	8.18	16
17	14.72	8.50	14.69	8.56	14.65	8.63	14.61	8.69	17
18	15.59	9.00	15.55	9.07	15.51	9.14	15.47	9.20	18
19	16.45	9.50	16.41	9.57	16.37	9.64	16.33	9.71	19
20	17.32	10.00	17.28	10.08	17.23	10.15	17.19	10.23	20
21	18.19	10.50	18.14	10.58	18.09	10.66	18.05	10.74	21
22	19.05	11.00	19.00	11.08	18.96	11.17	18.91	11.25	22
23	19.92	11.50	19.87	11.59	19.82	11.67	19.77	11.76	23
24	20.78	12.00	20.73	12.09	20.68	12.18	20.63	12.27	24
25	21.65	12.50	21.60	12.59	21.54	12.69	21.49	12.78	25
26	22.52	13.00	22.46	13.10	22.40	13.20	22.34	13.29	26
27	23.38	13.50	23.32	13.60	23.26	13.70	23.20	13.80	27
28	24.25	14.00	24.19	14.11	24.13	14.21	24.06	14.32	28
29	25.11	14.50	25.05	14.61	24.99	14.72	24.92	14.83	29
30	25.98	15.00	25.92	15.11	25.85	15.23	25.78	15.34	30
31	26.85	15.50	26.78	15.62	26.71	15.73	26.64	15.85	31
32	27.71	16.00	27.64	16.12	27.57	16.24	27.50	16.36	32
33	28.58	16.50	28.51	16.62	28.43	16.75	28.36	16.87	33
34	29.44	17.00	29.37	17.13	29.30	17.26	29.22	17.38	34
35	30.31	17.50	30.23	17.63	30.16	17.76	30.08	17.90	35
36	31.18	18.00	31.10	18.14	31.02	18.27	30.94	18.41	36
37	32.04	18.50	31.96	18.64	31.88	18.78	31.80	18.92	37
38	32.91	19.00	32.83	19.14	32.74	19.29	32.66	19.43	38
39	33.77	19.50	33.69	19.65	33.60	19.79	33.52	19.94	39
40	34.64	20.00	34.55	20.15	34.47	20.30	34.38	20.45	40
41	35.51	20.50	35.42	20.65	35.33	20.81	35.24	20.96	41
42	36.37	21.00	36.28	21.16	36.19	21.32	36.10	21.47	42
43	37.24	21.50	37.14	21.66	37.05	21.82	36.95	21.99	43
44	38.11	22.00	38.01	22.17	37.91	22.33	37.81	22.50	44
45	38.97	22.50	38.87	22.67	38.77	22.84	38.67	23.01	45
46	39.84	23.00	39.74	23.17	39.63	23.35	39.53	23.52	46
47	40.70	23.50	40.60	23.68	40.50	23.85	40.39	24.03	47
48	41.57	24.00	41.46	24.18	41.36	24.36	41.25	24.54	48
49	42.44	24.50	42.33	24.68	42.22	24.87	42.11	25.05	49
50	43.30	25.00	43.19	25.19	43.08	25.38	42.97	25.56	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	60 Deg.		59¾ Deg.		59½ Deg.		59¼ Deg.		

Distance.	30 Deg.		30¼ Deg.		30½ Deg.		30¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	44.17	25.50	44.06	25.69	43.94	25.88	43.83	26.08	51
52	45.03	26.00	44.92	26.20	44.80	26.39	44.69	26.59	52
53	45.90	26.50	45.78	26.70	45.67	26.90	45.55	27.10	53
54	46.77	27.00	46.65	27.20	46.53	27.41	46.41	27.61	54
55	47.63	27.50	47.51	27.71	47.39	27.91	47.27	28.12	55
56	48.50	28.00	48.37	28.21	48.25	28.42	48.13	28.63	56
57	49.36	28.50	49.24	28.72	49.11	28.93	48.99	29.14	57
58	50.23	29.00	50.10	29.22	49.97	29.44	49.85	29.65	58
59	51.10	29.50	50.97	29.72	50.84	29.94	50.70	30.17	59
60	51.96	30.00	51.83	30.23	51.70	30.45	51.56	30.68	60
61	52.83	30.50	52.69	30.73	52.56	30.96	52.42	31.19	61
62	53.69	31.00	53.56	31.23	53.42	31.47	53.28	31.70	62
63	54.56	31.50	54.42	31.74	54.28	31.97	54.14	32.21	63
64	55.43	32.00	55.29	32.24	55.14	32.48	55.00	32.72	64
65	56.29	32.50	56.15	32.75	56.01	32.99	55.86	33.23	65
66	57.16	33.00	57.01	33.25	56.87	33.50	56.72	33.75	66
67	58.02	33.50	57.88	33.75	57.73	34.01	57.58	34.26	67
68	58.89	34.00	58.74	34.26	58.59	34.51	58.44	34.77	68
69	59.76	34.50	59.60	34.76	59.45	35.02	59.30	35.28	69
70	60.62	35.00	60.47	35.26	60.31	35.53	60.16	35.79	70
71	61.49	35.50	61.33	35.77	61.18	36.04	61.02	36.30	71
72	62.35	36.00	62.20	36.27	62.04	36.54	61.88	36.81	72
73	63.22	36.50	63.06	36.78	62.90	37.05	62.74	37.32	73
74	64.09	37.00	63.92	37.28	63.76	37.56	63.60	37.84	74
75	64.95	37.50	64.79	37.78	64.62	38.07	64.46	38.35	75
76	65.82	38.00	65.65	38.29	65.48	38.57	65.31	38.86	76
77	66.68	38.50	66.52	38.79	66.35	39.08	66.17	39.37	77
78	67.55	39.00	67.38	39.29	67.21	39.59	67.03	39.88	78
79	68.42	39.50	68.24	39.80	68.07	40.10	67.89	40.39	79
80	69.28	40.00	69.11	40.30	68.93	40.60	68.75	40.90	80
81	70.15	40.50	69.97	40.81	69.79	41.11	69.61	41.41	81
82	71.01	41.00	70.83	41.31	70.65	41.62	70.47	41.93	82
83	71.88	41.50	71.70	41.81	71.52	42.13	71.33	42.44	83
84	72.75	42.00	72.56	42.32	72.38	42.63	72.19	42.95	84
85	73.61	42.50	73.43	42.82	73.24	43.14	73.05	43.46	85
86	74.48	43.00	74.29	43.32	74.10	43.65	73.91	43.97	86
87	75.34	43.50	75.15	43.83	74.96	44.16	74.77	44.48	87
88	76.21	44.00	76.02	44.33	75.82	44.66	75.63	44.99	88
89	77.08	44.50	76.88	44.84	76.68	45.17	76.49	45.51	89
90	77.94	45.00	77.75	45.34	77.55	45.68	77.35	46.02	90
91	78.81	45.50	78.61	45.84	78.41	46.19	78.21	46.53	91
92	79.67	46.00	79.47	46.35	79.27	46.69	79.07	47.04	92
93	80.54	46.50	80.34	46.85	80.13	47.20	79.92	47.55	93
94	81.41	47.00	81.20	47.35	80.99	47.71	80.78	48.06	94
95	82.27	47.50	82.06	47.86	81.85	48.22	81.64	48.57	95
96	83.14	48.00	82.93	48.36	82.72	48.72	82.50	49.08	96
97	84.00	48.50	83.79	48.87	83.58	49.23	83.36	49.60	97
98	84.87	49.00	84.66	49.37	84.44	49.74	84.22	50.11	98
99	85.74	49.50	85.52	49.87	85.30	50.25	85.08	50.62	99
100	86.60	50.00	86.38	50.38	86.16	50.75	85.94	51.13	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	60 Deg.		59¾ Deg.		59½ Deg.		59¼ Deg.		

Distance.	31 Deg.		31¼ Deg.		31½ Deg.		31¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.86	0.51	0.85	0.52	0.85	0.52	0.85	0.53	1
2	1.71	1.03	1.71	1.04	1.71	1.04	1.70	1.05	2
3	2.57	1.55	2.56	1.56	2.56	1.57	2.55	1.58	3
4	3.43	2.06	3.42	2.08	3.41	2.09	3.40	2.10	4
5	4.29	2.58	4.27	2.59	4.26	2.61	4.25	2.63	5
6	5.14	3.09	5.13	3.11	5.12	3.13	5.10	3.16	6
7	6.00	3.61	5.98	3.63	5.97	3.66	5.95	3.68	7
8	6.86	4.12	6.84	4.15	6.82	4.18	6.80	4.21	8
9	7.71	4.64	7.69	4.67	7.67	4.70	7.65	4.74	9
10	8.57	5.15	8.55	5.19	8.53	5.22	8.50	5.26	10
11	9.43	5.67	9.40	5.71	9.38	5.75	9.35	5.79	11
12	10.29	6.18	10.26	6.23	10.23	6.27	10.20	6.31	12
13	11.14	6.70	11.11	6.74	11.08	6.79	11.05	6.84	13
14	12.00	7.21	11.97	7.26	11.94	7.31	11.90	7.37	14
15	12.86	7.73	12.82	7.78	12.79	7.84	12.76	7.89	15
16	13.71	8.24	13.68	8.30	13.64	8.36	13.61	8.42	16
17	14.57	8.76	14.53	8.82	14.49	8.88	14.46	8.95	17
18	15.43	9.27	15.39	9.34	15.35	9.40	15.31	9.47	18
19	16.29	9.79	16.24	9.86	16.20	9.93	16.16	10.00	19
20	17.14	10.30	17.10	10.38	17.05	10.45	17.01	10.52	20
21	18.00	10.82	17.95	10.89	17.91	10.97	17.86	11.05	21
22	18.86	11.33	18.81	11.41	18.76	11.49	18.71	11.58	22
23	19.71	11.85	19.66	11.93	19.61	12.02	19.56	12.10	23
24	20.57	12.36	20.[illegible]2	12.45	20.46	12.54	20.41	12.63	24
25	21.43	12.88	21.37	12.97	21.32	13.06	21.26	13.16	25
26	22.29	13.39	22.23	13.49	22.17	13.58	22.11	13.68	26
27	23.14	13.91	23.08	14.01	23.02	14.11	22.96	14.21	27
28	24.00	14.42	23.94	14.53	23.87	14.63	23.81	14.73	28
29	24.86	14.94	24.79	15.04	24.73	15.15	24.66	15.26	29
30	25.71	15.45	25.65	15.56	25.58	15.67	25.51	15.79	30
31	26.57	15.97	26.50	16.08	26.43	16.20	26.36	16.31	31
32	27.43	16.48	27.36	16.60	27.28	16.72	27.21	16.84	32
33	28.29	17.00	28.21	17.12	28.14	17.24	28.06	17.37	33
34	29.14	17.51	29.07	17.64	28.99	17.76	28.91	17.89	34
35	30.00	18.03	29.92	18.16	29.84	18.29	29.76	18.42	35
36	30.86	18.54	30.78	18.68	30.70	18.81	30.61	18.94	36
37	31.72	19.06	31.63	19.19	31.55	19.33	31.46	19.47	37
38	32.57	19.57	32.49	19.71	32.40	19.85	32.31	20.00	38
39	33.43	20.09	33.34	20.23	33.25	20.38	33.16	20.52	39
40	34.29	20.60	34.20	20.75	34.11	20.90	34.01	21.05	40
41	35.14	21.12	35.05	21.27	34.96	21.42	34.86	21.57	41
42	36.00	21.63	35.91	21.79	35.81	21.94	35.71	22.10	42
43	36.86	22.15	36.76	22.31	36.66	22.47	36.57	22.63	43
44	37.72	22.66	37.62	22.83	37.52	22.99	37.42	23.15	44
45	38.57	23.18	38.47	23.34	38.37	23.51	38.27	23.68	45
46	39.43	23.69	39.33	23.86	39.22	24.03	39.12	24.21	46
47	40.29	24.21	40.18	24.38	40.07	24.56	39.97	24.73	47
48	41.14	24.72	41.04	24.90	40.93	25.08	40.82	25.26	48
49	42.00	25.24	41.89	25.42	41.78	25.60	41.67	25.78	49
50	42.86	25.75	42.75	25.94	42.63	26.12	42.52	26.31	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	59 Deg.		58¾ Deg.		58½ Deg.		58¼ Deg.		

Distance.	31 Deg.		31¼ Deg.		31½ Deg.		31¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	43.72	26.27	43.60	26.46	43.48	26.65	43.37	26.84	51
52	44.57	26.78	44.46	26.98	44.34	27.17	44.22	27.36	52
53	45.43	27.30	45.31	27.49	45.19	27.69	45.07	27.89	53
54	46.29	27.81	46.17	28.01	46.04	28.21	45.92	28.42	54
55	47.14	28.33	47.02	28.53	46.90	28.74	46.77	28.94	55
56	48.00	28.84	47.88	29.05	47.75	29.26	47.62	29.47	56
57	48.86	29.36	48.73	29.57	48.60	29.78	48.47	29.99	57
58	49.72	29.87	49.58	30.09	49.45	30.30	49.32	30.52	58
59	50.57	30.39	50.44	30.61	50.31	30.83	50.17	31.05	59
60	51.43	30.90	51.29	31.13	51.16	31.35	51.02	31.57	60
61	52.29	31.42	52.15	31.65	52.01	31.87	51.87	32.10	61
62	53.14	31.93	53.00	32.16	52.86	32.39	52.72	32.63	62
63	54.00	32.45	53.86	32.68	53.72	32.92	53.57	33.15	63
64	54.86	32.96	54.71	33.20	54.57	33.44	54.42	33.68	64
65	55.72	33.48	55.57	33.72	55.42	33.96	55.27	34.20	65
66	56.57	33.99	56.42	34.24	56.27	34.48	56.12	34.73	66
67	57.43	34.51	57.28	34.76	57.13	35.01	56.98	35.26	67
68	58.29	35.02	58.13	35.28	57.98	35.53	57.82	35.78	68
69	59.14	35.54	58.99	35.80	58.83	36.05	58.67	36.31	69
70	60.00	36.05	59.84	36.31	59.68	36.57	59.52	36.83	70
71	60.86	36.57	60.70	36.83	60.54	37.10	60.37	37.36	71
72	61.72	37.08	61.55	37.35	61.39	37.62	61.23	37.89	72
73	62.57	37.60	62.41	37.87	62.24	38.14	62.08	38.41	73
74	63.43	38.11	63.26	38.39	63.10	38.66	62.93	38.94	74
75	64.29	38.63	64.12	38.91	63.95	39.19	63.78	39.47	75
76	65.14	39.14	64.97	39.43	64.80	39.71	64.63	39.99	76
77	66.00	39.66	65.83	39.95	65.65	40.23	65.48	40.52	77
78	66.86	40.17	66.68	40.46	66.51	40.75	66.33	41.04	78
79	67.72	40.69	67.54	40.98	67.36	41.28	67.18	41.57	79
80	68.57	41.20	68.39	41.50	68.21	41.80	68.03	42.10	80
81	69.43	41.72	69.25	42.02	69.06	42.32	68.88	42.62	81
82	70.29	42.23	70.10	42.54	69.92	42.84	69.73	43.15	82
83	71.14	42.75	70.96	43.06	70.77	43.37	70.58	43.68	83
84	72.00	43.26	71.81	43.58	71.62	43.89	71.43	44.20	84
85	72.86	43.78	72.67	44.10	72.47	44.41	72.28	44.73	85
86	73.72	44.29	73.52	44.61	73.33	44.93	73.13	45.25	86
87	74.57	44.81	74.38	45.13	74.18	45.46	73.98	45.78	87
88	75.43	45.32	75.23	45.65	75.03	45.98	74.83	46.31	88
89	76.29	45.84	76.09	46.17	75.88	46.50	75.68	46.83	89
90	77.15	46.35	76.94	46.69	76.74	47.02	76.53	47.36	90
91	78.00	46.87	77.80	47.21	77.59	47.55	77.38	47.89	91
92	78.86	47.38	78.65	47.73	78.44	48.07	78.23	48.41	92
93	79.72	47.90	79.51	48.25	79.30	48.59	79.08	48.94	93
94	80.57	48.41	80.36	48.76	80.15	49.11	79.93	49.47	94
95	81.43	48.93	81.22	49.28	81.00	49.64	80.78	49.99	95
96	82.29	49.44	82.07	49.80	81.85	50.16	81.63	50.52	96
97	83.15	49.96	82.93	50.32	82.71	50.68	82.48	51.04	97
98	84.00	50.47	83.78	50.84	83.56	51.20	83.33	51.57	98
99	84.86	50.99	84.64	51.36	84.41	51.73	84.18	52.10	99
100	85.72	51.50	85.49	51.88	85.26	52.25	85.04	52.62	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	59 Deg.		58¾ Deg.		58½ Deg.		58¼ Deg.		

Distance.	32 Deg.		32¼ Deg.		32½ Deg.		32¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.85	0.53	0.85	0.53	0.84	0.54	0.84	0.54	1
2	1.70	1.06	1.69	1.07	1.69	1.07	1.68	1.08	2
3	2.54	1.59	2.54	1.60	2.53	1.61	2.52	1.62	3
4	3.39	2.12	3.38	2.13	3.37	2.15	3.36	2.16	4
5	4.24	2.65	4.23	2.67	4.22	2.69	4.21	2.70	5
6	5.09	3.18	5.07	3.20	5.06	3.22	5.05	3.25	6
7	5.94	3.71	5.92	3.74	5.90	3.76	5.89	3.79	7
8	6.78	4.24	6.77	4.27	6.75	4.30	6.73	4.33	8
9	7.63	4.77	7.61	4.80	7.59	4.84	7.57	4.87	9
10	8.48	5.30	8.46	5.34	8.43	5.37	8.41	5.41	10
11	9.33	5.83	9.30	5.87	9.28	5.91	9.25	5.95	11
12	10.18	6.36	10.15	6.40	10.12	6.45	10.09	6.49	12
13	11.02	6.89	10.99	6.94	10.96	6.98	10.93	7.03	13
14	11.87	7.42	11.84	7.47	11.81	7.52	11.77	7.57	14
15	12.72	7.95	12.69	8.00	12.65	8.06	12.62	8.11	15
16	13.57	8.48	13.53	8.54	13.49	8.60	13.46	8.66	16
17	14.42	9.01	14.38	9.07	14.34	9.13	14.30	9.20	17
18	15.26	9.54	15.22	9.61	15.18	9.67	15.14	9.74	18
19	16.11	10.07	16.07	10.14	16.02	10.21	15.98	10.28	19
20	16.96	10.60	16.91	10.67	16.87	10.75	16.82	10.82	20
21	17.81	11.13	17.76	11.21	17.71	11.28	17.66	11.36	21
22	18.66	11.66	18.61	11.74	18.55	11.82	18.50	11.90	22
23	19.51	12.19	19.45	12.27	19.40	12.36	19.34	12.44	23
24	20.35	12.72	20.30	12.81	20.24	12.90	20.18	12.98	24
25	21.20	13.25	21.14	13.34	21.08	13.43	21.03	13.52	25
26	22.05	13.78	21.99	13.87	21.93	13.97	21.87	14.07	26
27	22.90	14.31	22.83	14.41	22.77	14.51	22.71	14.61	27
28	23.75	14.84	23.68	14.94	23.61	15.04	23.55	15.15	28
29	24.59	15.37	24.53	15.47	24.46	15.58	24.39	15.69	29
30	25.44	15.90	25.37	16.01	25.30	16.12	25.23	16.23	30
31	26.29	16.43	26.22	16.54	26.15	16.66	26.07	16.77	31
32	27.14	16.96	27.06	17.08	26.99	17.19	26.91	17.31	32
33	27.99	17.49	27.91	17.61	27.83	17.73	27.75	17.85	33
34	28.83	18.02	28.75	18.14	28.68	18.27	28.60	18.39	34
35	29.68	18.55	29.60	18.68	29.52	18.81	29.44	18.93	35
36	30.53	19.08	30.45	19.21	30.36	19.34	30.28	19.48	36
37	31.38	19.61	31.29	19.74	31.21	19.88	31.12	20.02	37
38	32.23	20.14	32.14	20.28	32.05	20.42	31.96	20.56	38
39	33.07	20.67	32.98	20.81	32.89	20.95	32.80	21.10	39
40	33.92	21.20	33.83	21.34	33.74	21.49	33.64	21.64	40
41	34.77	21.73	34.67	21.88	34.58	22.03	34.48	22.18	41
42	35.62	22.26	35.52	22.41	35.42	22.57	35.32	22.72	42
43	36.47	22.79	36.37	22.95	36.27	23.10	36.16	23.26	43
44	37.31	23.32	37.21	23.48	37.11	23.64	37.01	23.80	44
45	38.16	23.85	38.06	24.01	37.95	24.18	37.85	24.34	45
46	39.01	24.38	38.90	24.55	38.80	24.72	38.69	24.88	46
47	39.86	24.91	39.75	25.08	39.64	25.25	39.53	25.43	47
48	40.71	25.44	40.59	25.61	40.48	25.79	40.37	25.97	48
49	41.55	25.97	41.44	26.15	41.33	26.33	41.21	26.51	49
50	42.40	26.50	42.29	26.68	42.17	26.86	42.05	27.05	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	58 Deg.		57¾ Deg.		57½ Deg.		57¼ Deg.		

Distance.	32 Deg.		32¼ Deg.		32½ Deg.		32¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	43.25	27.03	43.13	27.21	43.01	27.40	42.89	27.59	51
52	44.10	27.56	43.98	27.75	43.86	27.94	43.73	28.13	52
53	44.95	28.09	44.82	28.28	44.70	28.48	44.58	28.67	53
54	45.79	28.62	45.67	28.82	45.54	29.01	45.42	29.21	54
55	46.64	29.15	46.51	29.35	46.39	29.55	46.26	29.75	55
56	47.49	29.68	47.36	29.88	47.23	30.09	47.10	30.29	56
57	48.34	30.21	48.21	30.42	48.07	30.63	47.94	30.84	57
58	49.19	30.74	49.05	30.95	48.92	31.16	48.78	31.38	58
59	50.03	31.27	49.90	31.48	49.76	31.70	49.62	31.92	59
60	50.88	31.80	50.74	32.02	50.60	32.24	50.46	32.46	60
61	51.73	32.33	51.59	32.55	51.45	32.78	51.30	33.00	61
62	52.58	32.85	52.44	33.08	52.29	33.31	52.14	33.54	62
63	53.43	33.38	53.28	33.62	53.13	33.85	52.99	34.08	63
64	54.28	33.91	54.13	34.15	53.98	34.39	53.83	34.62	64
65	55.12	34.44	54.97	34.68	54.82	34.92	54.67	35.16	65
66	55.97	34.97	55.82	35.22	55.66	35.46	55.51	35.70	66
67	56.82	35.50	56.66	35.75	56.51	36.00	56.35	36.25	67
68	57.67	36.03	57.51	36.29	57.35	36.54	57.19	36.79	68
69	58.52	36.56	58.36	36.82	58.19	37.07	58.03	37.33	69
70	59.36	37.09	59.20	37.35	59.04	37.61	58.87	37.87	70
71	60.21	37.62	60.05	37.89	59.88	38.15	59.71	38.41	71
72	61.06	38.15	60.89	38.42	60.72	38.69	60.55	38.95	72
73	61.91	38.68	61.74	38.95	61.57	39.22	61.40	39.49	73
74	62.76	39.21	62.58	39.49	62.41	39.76	62.24	40.03	74
75	63.60	39.74	63.43	40.02	63.25	40.30	63.08	40.57	75
76	64.45	40.27	64.28	40.55	64.10	40.83	63.92	41.11	76
77	65.30	40.80	65.12	41.09	64.94	41.37	64.76	41.65	77
78	66.15	41.33	65.97	41.62	65.78	41.91	65.60	42.20	78
79	67.00	41.86	66.81	42.16	66.63	42.45	66.44	42.74	79
80	67.84	42.39	67.66	42.69	67.47	42.98	67.28	43.28	80
81	68.69	42.92	68.50	43.22	68.31	43.52	68.12	43.82	81
82	69.54	43.45	69.35	43.76	69.16	44.06	68.97	44.36	82
83	70.39	43.98	70.20	44.29	70.00	44.60	69.81	44.90	83
84	71.24	44.51	71.04	44.82	70.84	45.13	70.65	45.44	84
85	72.08	45.04	71.89	45.36	71.69	45.67	71.49	45.98	85
86	72.93	45.57	72.73	45.89	72.53	46.21	72.33	46.52	86
87	73.78	46.10	73.58	46.42	73.38	46.75	73.17	47.06	87
88	74.63	46.63	74.42	46.96	74.22	47.28	74.01	47.61	88
89	75.48	47.16	75.27	47.49	75.06	47.82	74.85	48.15	89
90	76.32	47.69	76.12	48.03	75.91	48.36	75.69	48.69	90
91	77.17	48.22	76.96	48.56	76.75	48.89	76.53	49.23	91
92	78.02	48.75	77.81	49.09	77.59	49.43	77.38	49.77	92
93	78.87	49.28	78.65	49.63	78.44	49.97	78.22	50.31	93
94	79.72	49.81	79.50	50.16	79.28	50.51	79.06	50.85	94
95	80.56	50.34	80.34	50.69	80.12	51.04	79.90	51.39	95
96	81.41	50.87	81.19	51.23	80.97	51.58	80.74	51.93	96
97	82.26	51.40	82.04	51.76	81.81	52.12	81.58	52.47	97
98	83.11	51.93	82.88	52.29	82.65	52.66	82.42	53.02	98
99	83.96	52.46	83.73	52.83	83.50	53.19	83.26	53.56	99
100	84.80	52.99	84.57	53.36	84.34	53.73	84.10	54.10	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	58 Deg.		57¾ Deg.		57½ Deg.		57¼ Deg.		

Distance.	33 Deg.		33¼ Deg.		33½ Deg.		33¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.84	0.54	0.84	0.55	0.83	0.55	0.83	0.56	1
2	1.68	1.09	1.67	1.10	1.67	1.10	1.66	1.11	2
3	2.52	1.63	2.51	1.64	2.50	1.66	2.49	1.67	3
4	3.35	2.18	3.35	2.19	3.34	2.21	3.33	2.22	4
5	4.19	2.72	4.18	2.74	4.17	2.76	4.16	2.78	5
6	5.03	3.27	5.02	3.29	5.00	3.31	4.99	3.33	6
7	5.87	3.81	5.85	3.84	5.84	3.86	5.82	3.89	7
8	6.71	4.36	6.69	4.39	6.67	4.42	6.65	4.44	8
9	7.55	4.90	7.53	4.93	7.50	4.97	7.48	5.00	9
10	8.39	5.45	8.36	5.48	8.34	5.52	8.31	5.56	10
11	9.23	5.99	9.20	6.03	9.17	6.07	9.15	6.11	11
12	10.06	6.54	10.04	6.58	10.01	6.62	9.98	6.67	12
13	10.90	7.08	10.87	7.13	10.84	7.18	10.81	7.22	13
14	11.74	7.62	11.71	7.68	11.67	7.73	11.64	7.78	14
15	12.58	8.17	12.54	8.22	12.51	8.28	12.47	8.33	15
16	13.42	8.71	13.38	8.77	13.34	8.83	13.30	8.89	16
17	14.26	9.26	14.22	9.32	14.18	9.38	14.13	9.44	17
18	15.10	9.80	15.05	9.87	15.01	9.93	14.97	10.00	18
19	15.93	10.35	15.89	10.42	15.84	10.49	15.80	10.56	19
20	16.77	10.89	16.73	10.97	16.68	11.04	16.63	11.11	20
21	17.61	11.44	17.56	11.51	17.51	11.59	17.46	11.67	21
22	18.45	11.98	18.40	12.06	18.35	12.14	18.29	12.22	22
23	19.29	12.53	19.23	12.61	19.18	12.69	19.12	12.78	23
24	20.13	13.07	20.07	13.16	20.01	13.25	19.96	13.33	24
25	20.97	13.62	20.91	13.71	20.85	13.80	20.79	13.89	25
26	21.81	14.16	21.74	14.26	21.68	14.35	21.62	14.44	26
27	22.64	14.71	22.58	14.80	22.51	14.90	22.45	15.00	27
28	23.48	15.25	23.42	15.35	23.35	15.45	23.28	15.56	28
29	24.32	15.79	24.25	15.90	24.18	16.01	24.11	16.11	29
30	25.16	16.34	25.09	16.45	25.02	16.56	24.94	16.67	30
31	26.00	16.88	25.92	17.00	25.85	17.11	25.78	17.22	31
32	26.84	17.43	26.76	17.55	26.68	17.66	26.61	17.78	32
33	27.68	17.97	27.60	18.09	27.52	18.21	27.44	18.33	33
34	28.51	18.52	28.43	18.64	28.35	18.77	28.27	18.89	34
35	29.35	19.06	29.27	19.19	29.19	19.32	29.10	19.44	35
36	30.19	19.61	30.11	19.74	30.02	19.87	29.93	20.00	36
37	31.03	20.15	30.94	20.29	30.85	20.42	30.76	20.56	37
38	31.87	20.70	31.78	20.84	31.69	20.97	31.60	21.11	38
39	32.71	21.24	32.62	21.38	32.52	21.53	32.43	21.67	39
40	33.55	21.79	33.45	21.93	33.36	22.08	33.26	22.22	40
41	34.39	22.33	34.29	22.48	34.19	22.63	34.09	22.78	41
42	35.22	22.87	35.12	23.03	35.02	23.18	34.92	23.33	42
43	36.06	23.42	35.96	23.58	35.86	23.73	35.75	23.89	43
44	36.90	23.96	36.80	24.12	36.69	24.29	36.58	24.45	44
45	37.74	24.51	37.63	24.67	37.52	24.84	37.42	25.00	45
46	38.58	25.05	38.47	25.22	38.36	25.39	38.25	25.56	46
47	39.42	25.60	39.31	25.77	39.19	25.94	39.08	26.11	47
48	40.26	26.14	40.14	26.32	40.03	26.49	39.91	26.67	48
49	41.09	26.69	40.98	26.87	40.86	27.04	40.74	27.22	49
50	41.93	27.23	41.81	27.41	41.69	27.60	41.57	27.78	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	57 Deg.		56¾ Deg.		56½ Deg.		56¼ Deg.		

Distance.	33 Deg.		33¼ Deg.		33½ Deg.		33¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	42.77	27.78	42.65	27.96	42.53	28.15	42.40	28.33	51
52	43.61	28.32	43.49	28.51	43.36	28.70	43.24	28.89	52
53	44.45	28.87	44.32	29.06	44.20	29.25	44.07	29.45	53
54	45.29	29.41	45.16	29.61	45.03	29.80	44.90	30.00	54
55	46.13	29.96	46.00	30.16	45.86	30.36	45.73	30.56	55
56	46.97	30.50	46.83	30.70	46.70	30.91	46.56	31.11	56
57	47.80	31.04	47.67	31.25	47.53	31.46	47.39	31.67	57
58	48.64	31.59	48.50	31.80	48.37	32.01	48.23	32.22	58
59	49.48	32.13	49.34	32.35	49.20	32.56	49.06	32.78	59
60	50.32	32.68	50.18	32.90	50.03	33.12	49.89	33.33	60
61	51.16	33.22	51.01	33.45	50.87	33.67	50.72	33.89	61
62	52.00	33.77	51.85	33.99	51.70	34.22	51.55	34.45	62
63	52.84	34.31	52.69	34.54	52.53	34.77	52.38	35.00	63
64	53.67	34.86	53.52	35.09	53.37	35.32	53.21	35.56	64
65	54.51	35.40	54.36	35.64	54.20	35.88	54.05	36.11	65
66	55.35	35.95	55.19	36.19	55.04	36.43	54.88	36.67	66
67	56.19	36.49	56.03	36.74	55.87	36.98	55.71	37.22	67
68	57.03	37.04	56.87	37.28	56.70	37.53	56.54	37.78	68
69	57.87	37.58	57.70	37.83	57.54	38.08	57.37	38.33	69
70	58.71	38.12	58.54	38.38	58.37	38.64	58.20	38.89	70
71	59.55	38.67	59.38	38.93	59.21	39.19	59.03	39.45	71
72	60.38	39.21	60.21	39.48	60.04	39.74	59.87	40.00	72
73	61.22	39.76	61.05	40.03	60.87	40.29	60.70	40.56	73
74	62.06	40.30	61.89	40.57	61.71	40.84	61.53	41.11	74
75	62.90	40.85	62.72	41.12	62.54	41.40	62.36	41.67	75
76	63.74	41.39	63.56	41.67	63.38	41.95	63.19	42.22	76
77	64.58	41.94	64.39	42.22	64.21	42.50	64.02	42.78	77
78	65.42	42.48	65.23	42.77	65.04	43.05	64.85	43.33	78
79	66.25	43.03	66.07	43.32	65.88	43.60	65.69	43.89	79
80	67.09	43.57	66.90	43.86	66.71	44.15	66.52	44.45	80
81	67.93	44.12	67.74	44.41	67.54	44.71	67.35	45.00	81
82	68.77	44.66	68.58	44.96	68.38	45.26	68.18	45.56	82
83	69.61	45.20	69.41	45.51	69.21	45.81	69.01	46.11	83
84	70.45	45.75	70.25	46.06	70.05	46.36	69.84	46.67	84
85	71.29	46.29	71.08	46.60	70.88	46.91	70.67	47.22	85
86	72.13	46.84	71.92	47.15	71.71	47.47	71.51	47.78	86
87	72.96	47.38	72.76	47.70	72.55	48.02	72.34	48.33	87
88	73.80	47.93	73.59	48.25	73.38	48.57	73.17	48.89	88
89	74.64	48.47	74.43	48.80	74.22	49.12	74.00	49.45	89
90	75.48	49.02	75.27	49.35	75.06	49.67	74.83	50.00	90
91	76.32	49.56	76.10	49.89	75.88	50.23	75.66	50.56	91
92	77.16	50.11	76.94	50.44	76.72	50.78	76.50	51.11	92
93	78.00	50.65	77.77	50.99	77.55	51.33	77.33	51.67	93
94	78.83	51.20	78.61	51.54	78.39	51.88	78.16	52.22	94
95	79.67	51.74	79.45	52.09	79.22	52.43	78.99	52.78	95
96	80.51	52.29	80.28	52.64	80.05	52.99	79.82	53.33	96
97	81.35	52.83	81.12	53.18	80.89	53.54	80.65	53.89	97
98	82.19	53.37	81.96	53.73	81.72	54.09	81.48	54.45	98
99	83.03	53.92	82.79	54.28	82.55	54.64	82.32	55.00	99
100	83.87	54.46	83.63	54.83	83.39	55.19	83.15	55.56	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	57 Deg.		56¾ Deg.		56½ Deg.		56¼ Deg.		

Distance.	34 Deg.		34¼ Deg.		34½ Deg.		34¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.83	0.56	0.83	0.56	0.82	0.57	0.82	0.57	1
2	1.66	1.12	1.65	1.13	1.65	1.13	1.64	1.14	2
3	2.49	1.68	2.48	1.69	2.47	1.70	2.46	1.71	3
4	3.32	2.24	3.31	2.25	3.30	2.27	3.29	2.28	4
5	4.15	2.80	4.13	2.81	4.12	2.83	4.11	2.85	5
6	4.97	3.36	4.96	3.38	4.94	3.40	4.93	3.42	6
7	5.80	3.91	5.79	3.94	5.77	3.96	5.75	3.99	7
8	6.63	4.47	6.61	4.50	6.59	4.53	6.57	4.56	8
9	7.46	5.03	7.44	5.07	7.42	5.10	7.39	5.13	9
10	8.29	5.59	8.27	5.63	8.24	5.66	8.22	5.70	10
11	9.12	6.15	9.09	6.19	9.07	6.23	9.04	6.27	11
12	9.95	6.71	9.92	6.75	9.89	6.80	9.86	6.84	12
13	10.78	7.27	10.75	7.32	10.71	7.36	10.68	7.41	13
14	11.61	7.83	11.57	7.88	11.54	7.93	11.50	7.98	14
15	12.44	8.39	12.40	8.44	12.36	8.50	12.32	8.55	15
16	13.26	8.95	13.23	9.00	13.19	9.06	13 15	9.12	16
17	14.09	9.51	14.05	9.57	14.01	9.63	13.97	9.69	17
18	14.92	10.07	14.88	10.13	14.83	10.20	14.79	10.26	18
19	15.75	10.62	15.71	10.69	15.66	10.76	15.61	10.83	19
20	16.58	11.18	16.53	11.26	16.48	11.33	16.43	11.40	20
21	17.41	11.74	17.36	11.82	17.31	11.89	17.25	11.97	21
22	18.24	12.30	18.18	12.38	18.13	12.46	18.08	12.54	22
23	19.07	12.86	19.01	12.94	18.95	13.03	18.90	13.11	23
24	19.90	13.42	19.84	13.51	19.78	13.59	19.72	13.68	24
25	20.73	13.98	20.66	14.07	20.60	14.16	20.54	14.25	25
26	21.55	14.54	21.49	14.63	21.43	14.73	21.36	14.82	26
27	22.38	15.10	22.32	15.20	22.25	15.29	22.18	15.39	27
28	23.21	15.66	23.14	15.76	23.08	15.86	23.01	15.96	28
29	24.04	16.22	23.97	16.32	23.90	16.43	23.83	16.53	29
30	24.87	16.78	24.80	16.88	24.72	16.99	24.65	17.10	30
31	25.70	17.33	25.62	17.45	25.55	17.56	25.47	17.67	31
32	26.53	17.89	26.45	18.01	26.37	18.12	26.29	18.24	32
33	27.36	18.45	27.28	18.57	27.20	18.69	27.11	18.81	33
34	28.19	19.01	28.10	19.14	28.02	19.26	27.94	19.38	34
35	29.02	19.57	28.93	19.70	28.84	19.82	28.76	19.95	35
36	29.85	20.13	29.76	20.26	29.67	20.39	29.58	20.52	36
37	30.67	20.69	30.58	20.82	30.49	20.96	30.40	21.09	37
38	31.50	21.25	31.41	21.39	31.32	21.52	31.22	21.66	38
39	32.33	21.81	32.24	21.95	32.14	22.09	32.04	22.23	39
40	33.16	22.37	33.06	22.51	32.97	22.66	32.87	22.80	40
41	33.99	22.93	33.89	23.07	33.79	23.22	33.69	23.37	41
42	34.82	23.49	34.72	23.64	34.61	23.79	34.51	23.94	42
43	35.65	24.05	35.54	24.20	35.44	24.36	35.33	24.51	43
44	36.48	24.60	36.37	24.76	36.26	24.92	36.15	25.08	44
45	37.31	25.16	37.20	25.33	37.09	25.49	36.97	25.65	45
46	38.14	25.72	38.02	25.89	37.91	26.05	37.80	26.22	46
47	38.96	26.28	38.85	26.45	38.73	26.62	38.62	26.79	47
48	39.79	26.84	39.68	27.01	39.56	27.19	39.44	27.36	48
49	40.62	27.40	40.50	27.58	40.38	27.75	40.26	27.93	49
50	41.45	27.96	41.33	28.14	41.21	28.32	41.08	28.50	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	56 Deg.		55¾ Deg.		55½ Deg.		55¼ Deg.		

Distance.	34 Deg.		34¼ Deg.		34½ Deg.		34¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	42.28	28.52	42.16	28.70	42.03	28.89	41.90	29.07	51
52	43.11	29.08	42.98	29.27	42.85	29.45	42.73	29.64	52
53	43.94	29.64	43.81	29.83	43.68	30.02	43.55	30.21	53
54	44.77	30.20	44.64	30.39	44.50	30.59	44.37	30.78	54
55	45.60	30.76	45.46	30.95	45.33	31.15	45.19	31.35	55
56	46.43	31.31	46.29	31.52	46.15	31.72	46.01	31.92	56
57	47.26	31.87	47.12	32.08	46.98	32.29	46.83	32.49	57
58	48.08	32.43	47.94	32.64	47.80	32.85	47.66	33.06	58
59	48.91	32.99	48.77	33.21	48.62	33.42	48.48	33.63	59
60	49.74	33.55	49.60	33.77	49.45	33.98	49.30	34.20	60
61	50.57	34.11	50.42	34.33	50.27	34.55	50.12	34.77	61
62	51.40	34.67	51.25	34.89	51.10	35.12	50.94	35.34	62
63	52.23	35.23	52.08	35.46	51.92	35.68	51.76	35.91	63
64	53.06	35.79	52.90	36.02	52.74	36.25	52.59	36.48	64
65	53.89	36.35	53.73	36.58	53.57	36.82	53.41	37.05	65
66	54.72	36.91	54.55	37.15	54.39	37.38	54.23	37.62	66
67	55.55	37.46	55.38	37.71	55.22	37.95	55.05	38.19	67
68	56.37	38.03	56.21	38.27	56.04	38.52	55.87	38.76	68
69	57.20	38.58	57.03	38.83	56.86	39.08	56.69	39.33	69
70	58.03	39.14	57.86	39.40	57.69	39.65	57.52	39.90	70
71	58.86	39.70	58.69	39.96	58.51	40.21	58.34	40.47	71
72	59.69	40.26	59.51	40.52	59.34	40.78	59.16	41.04	72
73	60.52	40.82	60.34	41.08	60.16	41.35	59.98	41.61	73
74	61.35	41.38	61.17	41.65	60.99	41.91	60.80	42.18	74
75	62.18	41.94	61.99	42.21	61.81	42.48	61.62	42.75	75
76	63.01	42.50	62.82	42.77	62.63	43.05	62.45	43.32	76
77	63.84	43.06	63.65	43.34	63.46	43.61	63.27	43.89	77
78	64.66	43.62	64.47	43.90	64.28	44.18	64.09	44.46	78
79	65.49	44.18	65.30	44.46	65.11	44.75	64.91	45.03	79
80	66.32	44.74	66.13	45.02	65.93	45.31	65.73	45.60	80
81	67.15	45.29	66.95	45.59	66.75	45.88	66.55	46.17	81
82	67.98	45.85	67.78	46.15	67.58	46.45	67.37	46.74	82
83	68.81	46.41	68.61	46.71	68.40	47.01	68.20	47.31	83
84	69.64	46.97	69.43	47.28	69.23	47.58	69.02	47.88	84
85	70.47	47.53	70.26	47.84	70.05	48.14	69.84	48.45	85
86	71.30	48.09	71.09	48.40	70.87	48.71	70.66	49.02	86
87	72.13	48.65	71.91	48.96	71.70	49.28	71.48	49.59	87
88	72.96	49.21	72.74	49.53	72.52	49.84	72.30	50.16	88
89	73.78	49.77	73.57	50.09	73.35	50.41	73.13	50.73	89
90	74.61	50.33	74.39	50.65	74.17	50.98	73.95	51.30	90
91	75.44	50.89	75.22	51.22	75.00	51.54	74.77	51.87	91
92	76.27	51.45	76.05	51.78	75.82	52.11	75.59	52.44	92
93	77.10	52.00	76.87	52.34	76.64	52.68	76.41	53.01	93
94	77.93	52.56	77.70	52.90	77.47	53.24	77.23	53.58	94
95	78.76	53.12	78.53	53.47	78.29	53.81	78.06	54.15	95
96	79.59	53.68	79.35	54.03	79.12	54.37	78.88	54.72	96
97	80.42	54.24	80.18	54.59	79.94	54.94	79.70	55.29	97
98	81.25	54.80	81.01	55.15	80.76	55.51	80.52	55.86	98
99	82.07	55.36	81.83	55.72	81.59	56.07	81.34	56.43	99
100	82.90	55.92	82.66	56.28	82.41	56.64	82.16	57.00	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	56 Deg.		55¾ Deg.		55½ Deg.		55¼ Deg.		

Distance.	35 Deg.		35¼ Deg.		35½ Deg.		35¾ Deg.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	0.82	0.57	0.82	0.58	0.81	0.58	0.81	0.58
2	1.64	1.15	1.63	1.15	1.63	1.16	1.62	1.17
3	2.46	1.72	2.45	1.73	2.44	1.74	2.43	1.75
4	3.28	2.29	3.27	2.31	3.26	2.32	3.25	2.34
5	4.10	2.87	4.08	2.89	4.07	2.90	4.06	2.92
6	4.91	3.44	4.90	3.46	4.88	3.48	4.87	3.51
7	5.73	4.01	5.72	4.04	5.70	4.06	5.68	4.09
8	6.55	4.59	6.53	4.62	6.51	4.65	6.49	4.67
9	7.37	5.16	7.35	5.19	7.33	5.23	7.30	5.26
10	8.19	5.74	8.17	5.77	8.14	5.81	8.12	5.84
11	9.01	6.31	8.98	6.35	8.96	6.39	8.93	6.43
12	9.83	6.88	9.80	6.93	9.77	6.97	9.74	7.01
13	10.65	7.46	10.62	7.50	10.58	7.55	10.55	7.60
14	11.47	8.03	11.43	8.08	11.40	8.13	11.36	8.18
15	12.29	8.60	12.25	8.66	12.21	8.71	12.17	8.76
16	13.11	9.18	13.07	9.23	13.03	9.29	12.99	9.35
17	13.93	9.75	13.88	9.81	13.84	9.87	13.80	9.93
18	14.74	10.32	14.70	10.39	14.65	10.45	14.61	10.52
19	15.56	10.90	15.52	10.97	15.47	11.03	15.42	11.10
20	16.38	11.47	16.33	11.54	16.28	11.61	16.23	11.68
21	17.20	12.05	17.15	12.12	17.10	12.19	17.04	12.27
22	18.02	12.62	17.97	12.70	17.91	12.78	17.85	12.85
23	18.84	13.19	18.78	13.27	18.72	13.36	18.67	13.44
24	19.66	13.77	19.60	13.85	19.54	13.94	19.48	14.02
25	20.48	14.34	20.42	14.43	20.35	14.52	20.29	14.61
26	21.30	14.91	21.23	15.01	21.17	15.10	21.10	15.19
27	22.12	15.49	22.05	15.58	21.98	15.68	21.91	15.77
28	22.94	16.06	22.87	16.16	22.80	16.26	22.72	16.36
29	23.76	16.63	23.68	16.74	23.61	16.84	23.54	16.94
30	24.57	17.21	24.50	17.31	24.42	17.42	24.35	17.53
31	25.39	17.78	25.32	17.89	25.24	18.00	25.16	18.11
32	26.21	18.35	26.13	18.47	26.05	18.58	25.97	18.70
33	27.03	18.93	26.95	19.05	26.87	19.16	26.78	19.28
34	27.85	19.50	27.77	19.62	27.68	19.74	27.59	19.86
35	28.67	20.08	28.58	20.20	28.49	20.32	28.41	20.45
36	29.49	20.65	29.40	20.78	29.31	20.91	29.22	21.03
37	30.31	21.22	30.22	21.35	30.12	21.49	30.03	21.62
38	31.13	21.80	31.03	21.93	30.94	22.07	30.84	22.20
39	31.95	22.37	31.85	22.51	31.75	22.65	31.65	22.79
40	32.77	22.94	32.67	23.09	32.56	23.23	32.46	23.37
41	33.59	23.52	33.48	23.66	33.38	23.81	33.27	23.95
42	34.40	24.09	34.30	24.24	34.19	24.39	34.09	24.54
43	35.22	24.66	35.12	24.82	35.01	24.97	34.90	25.12
44	36.04	25.24	35.93	25.39	35.82	25.55	35.71	25.71
45	36.86	25.81	36.75	25.97	36.64	26.13	36.52	26.29
46	37.68	26.38	37.57	26.55	37.45	26.71	37.33	26.88
47	38.50	26.96	38.38	27.13	38.26	27.29	38.14	27.46
48	39.32	27.53	39.20	27.70	39.08	27.87	38.96	28.04
49	40.14	28.11	40.02	28.28	39.89	28.45	39.77	28.63
50	40.96	28.68	40.83	28.86	40.71	29.04	40.58	29.21
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	55 Deg.		54¾ Deg.		54½ Deg.		54¼ Deg.	

Distance.	35 Deg.		35¼ Deg.		35½ Deg.		35¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	41.78	29.25	41.65	29.43	41.52	29.62	41.39	29.80	51
52	42.60	29.83	42.47	30.01	42.33	30.20	42.20	30.38	52
53	43.42	30.40	43.28	30.59	43.15	30.78	43.01	30.97	53
54	44.23	30.97	44.10	31.17	43.96	31.36	43.82	31.55	54
55	45.05	31.55	44.92	31.74	44.78	31.94	44.64	32.13	55
56	45.87	32.12	45.73	32.32	45.59	32.52	45.45	32.72	56
57	46.69	32.69	46.55	32.90	46.40	33.10	46.26	33.30	57
58	47.51	33.27	47.37	33.47	47.22	33.68	47.07	33.89	58
59	48.33	33.84	48.18	34.05	48.03	34.26	47.88	34.47	59
60	49.15	34.41	49.00	34.63	48.85	34.84	48.69	35.05	60
61	49.97	34.99	49.82	35.21	49.66	35.42	49.51	35.64	61
62	50.79	35.56	50.63	35.78	50.48	36.00	50.32	36.22	62
63	51.61	36.14	51.45	36.36	51.29	36.58	51.13	36.81	63
64	52.43	36.71	52.27	36.94	52.10	37.16	51.94	37.39	64
65	53.24	37.28	53.08	37.51	52.92	37.75	52.75	37.98	65
66	54.06	37.86	53.90	38.09	53.73	38.33	53.56	38.56	66
67	54.88	38.43	54.71	38.67	54.55	38.91	54.38	39.14	67
68	55.70	39.00	55.53	39.25	55.36	39.49	55.19	39.73	68
69	56.52	39.58	56.35	39.82	56.17	40.07	56.00	40.31	69
70	57.34	40.15	57.16	40.40	56.99	40.65	56.81	40.90	70
71	58.16	40.72	57.98	40.98	57.80	41.23	57.62	41.48	71
72	58.98	41.30	58.80	41.55	58.62	41.81	58.43	42.07	72
73	59.80	41.87	59.61	42.13	59.43	42.39	59.24	42.65	73
74	60.62	42.44	60.43	42.71	60.24	42.97	60.06	43.23	74
75	61.44	43.02	61.25	43.29	61.06	43.55	60.87	43.82	75
76	62.26	43.59	62.06	43.86	61.87	44.13	61.68	44.40	76
77	63.07	44.17	62.88	44.44	62.69	44.71	62.49	44.99	77
78	63.89	44.74	63.70	45.02	63.50	45.29	63.30	45.57	78
79	64.71	45.31	64.51	45.59	64.32	45.88	64.11	46.16	79
80	65.53	45.89	65.33	46.17	65.13	46.46	64.93	46.74	80
81	66.35	46.46	66.15	46.75	65.94	47.04	65.74	47.32	81
82	67.17	47.03	66.96	47.33	66.76	47.62	66.55	47.91	82
83	67.99	47.61	67.78	47.90	67.57	48.20	67.36	48.49	83
84	68.81	48.18	68.60	48.48	68.39	48.78	68.17	49.08	84
85	69.63	48.75	69.41	49.06	69.20	49.36	68.98	49.66	85
86	70.45	49.33	70.23	49.63	70.01	49.94	69.80	50.25	86
87	71.27	49.90	71.05	50.21	70.83	50.52	70.61	50.83	87
88	72.09	50.47	71.86	50.79	71.64	51.10	71.42	51.41	88
89	72.90	51.05	72.68	51.37	72.46	51.68	72.23	52.00	89
90	73.72	51.62	73.50	51.94	73.27	52.26	73.04	52.58	90
91	74.54	52.20	74.31	52.52	74.08	52.84	73.85	53.17	91
92	75.36	52.77	75.13	53.10	74.90	53.42	74.66	53.75	92
93	76.18	53.34	75.95	53.67	75.71	54.01	75.48	54.34	93
94	77.00	53.92	76.76	54.25	76.53	54.59	76.29	54.92	94
95	77.82	54.49	77.58	54.83	77.34	55.17	77.10	55.50	95
96	78.64	55.06	78.40	55.41	78.16	55.75	77.91	56.09	96
97	79.46	55.64	79.21	55.98	78.97	56.33	78.72	56.67	97
98	80.28	56.21	80.03	56.56	79.78	56.91	79.53	57.26	98
99	81.10	56.78	80.85	57.14	80.60	57.49	80.35	57.84	99
100	81.92	57.36	81.66	57.71	81.41	58.07	81.16	58.42	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	55 Deg.		54¾ Deg.		54½ Deg.		54¼ Deg.		

Distance.	36 Deg.		36¼ Deg.		36½ Deg.		36¾ Deg.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	0.81	0.59	0.81	0.59	0.80	0.59	0.80	0.60
2	1.62	1.18	1.61	1.18	1.61	1.19	1.60	1.20
3	2.43	1.76	2.42	1.77	2.41	1.78	2.40	1.79
4	3.24	2.35	3.23	2.37	3.22	2.38	3.20	2.39
5	4.05	2.94	4.03	2.96	4.02	2.97	4.01	2.99
6	4.85	3.53	4.84	3.55	4.82	3.57	4.81	3.59
7	5.66	4.11	5.65	4.14	5.63	4.16	5.61	4.19
8	6.47	4.70	6 45	4.73	6.43	4.76	6.41	4.79
9	7.28	5.29	7.26	5.32	7.23	5.35	7.21	5.38
10	8.09	5.88	8.06	5.91	8.04	5.95	8.01	5.98
11	8.90	6.47	8.87	6.50	8.84	6.54	8.81	6.58
12	9.71	7.05	9.68	7.10	9.65	7.14	9.61	7.18
13	10.52	7.64	10.48	7.69	10.45	7.73	10.42	7.78
14	11.33	8.23	11.29	8.28	11.25	8.33	11.22	8.38
15	12.14	8.82	12.10	8.87	12.06	8.92	12.02	8.97
16	12.94	9.40	12.90	9.46	12.86	9.52	12.82	9.57
17	13.75	9.99	13.71	10.05	13.67	10.11	13.62	10.17
18	14.56	10.58	14.52	10.64	14.47	10.71	14.42	10.77
19	15.37	11.17	15.32	11.23	15.27	11.30	15.22	11.37
20	16.18	11.76	16.13	11.83	16.08	11.90	16.03	11.97
21	16.99	12.34	16.94	12.42	16.88	12.49	16.83	12.56
22	17.80	12.93	17.74	13.01	17.68	13.09	17.63	13.16
23	18.61	13.52	18.55	13.60	18.49	13.68	18.43	13.76
24	19.42	14.11	19.35	14.19	19.29	14.28	19.23	14.36
25	20.23	14.69	20.16	14.78	20.10	14.87	20.03	14.96
26	21.03	15.28	20.97	15.37	20.90	15.47	20.83	15.56
27	21.84	15.87	21.77	15.97	21.70	16.06	21.63	16.15
28	22.65	16.46	22.58	16.56	22.51	16.65	22.44	16.75
29	23.46	17.05	23.39	17.15	23.31	17.25	23.24	17.35
30	24.27	17.63	24.19	17.74	24.12	17.84	24.04	17.95
31	25.08	18.22	25.00	18.33	24.92	18.44	24.84	18.55
32	25.89	18.81	25.81	18.92	25.72	19.03	25.64	19.15
33	26.70	19.40	26.61	19.51	26.53	19.63	26.44	19.74
34	27.51	19.98	27.42	20.10	27.33	20.22	27.24	20.34
35	28.32	20.57	28.23	20.70	28.13	20.82	28.04	20.94
36	29.12	21.16	29.03	21.29	28.94	21.41	28.85	21.54
37	29.93	21.75	29.84	21.88	29.74	22.01	29.65	22.14
38	30.74	22.34	30.64	22.47	30.55	22.60	30.45	22.74
39	31.55	22.92	31.45	23.06	31.35	23.20	31.25	23.33
40	32.36	23.51	32.26	23.65	32.15	23.79	32.05	23.93
41	33.17	24.10	33.06	24.24	32.96	24.39	32.85	24.53
42	33.98	24.69	33.87	24.83	33.76	24.98	33.65	25.13
43	34.79	25.27	34.68	25.43	34.57	25.58	34.45	25.73
44	35.60	25.86	35.48	26.02	35.37	26.17	35.26	26.33
45	36.41	26.45	36.29	26.61	36.17	26.77	36.06	26.92
46	37.21	27.04	37.10	27.20	36.98	27.36	36.86	27.52
47	38.02	27.63	37.90	27.79	37.78	27.96	37.66	28.12
48	38.83	28.21	38.71	28.38	38.59	28.55	38.46	28.72
49	39.64	28.80	39.52	28.97	39.39	29.15	39.26	29.32
50	40.45	29.39	40.32	29.57	40.19	29.74	40.06	29.92
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	54 Deg.		53¾ Deg.		53½ Deg.		53¼ Deg.	

Distance.	36 Deg.		36¼ Deg.		36½ Deg.		36¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	41.26	29.98	41.13	30.16	41.00	30.34	40.86	30.51	51
52	42.07	30.56	41.94	30.75	41.80	30.93	41.67	31.11	52
53	42.88	31.15	42.74	31.34	42.60	31.53	42.47	31.71	53
54	43.69	31.74	43.55	31.93	43.41	32.12	43.27	32.31	54
55	44.50	32.33	44.35	32.52	44.21	32.72	44.07	32.91	55
56	45.30	32.92	45.16	33.11	45.02	33.31	44.87	33.51	56
57	46.11	33.50	45.97	33.70	45.82	33.90	45.67	34.10	57
58	46.92	34.09	46.77	34.30	46.62	34.50	46.47	34.70	58
59	47.73	34.68	47.58	34.89	47.43	35.09	47.27	35.30	59
60	48.54	35.27	48.39	35.48	48.23	35.69	48.08	35.90	60
61	49.35	35.85	49.19	36.07	49.04	36.28	48.88	36.50	61
62	50.16	36.44	50.00	36.66	49.84	36.88	49.68	37.10	62
63	50.97	37.03	50.81	37.25	50.64	37.47	50.48	37.69	63
64	51.78	37.62	51.61	37.84	51.45	38.07	51.28	38.29	64
65	52.59	38.21	52.42	38.44	52.25	38.66	52.08	38.89	65
66	53.40	38.79	53.23	39.03	53.05	39.26	52.88	39.49	66
67	54.20	39.38	54.03	39.62	53.86	39.85	53.68	40.09	67
68	55.01	39.97	54.84	40.21	54.66	40.45	54.49	40.69	68
69	55.82	40.56	55.64	40.80	55.47	41.04	55.29	41.28	69
70	56.63	41.14	56.45	41.39	56.27	41.64	56.09	41.88	70
71	57.44	41.73	57.26	41.98	57.07	42.23	56.89	42.48	71
72	58.25	42.32	58.06	42.57	57.88	42.83	57.69	43.08	72
73	59.06	42.91	58.87	43.17	58.68	43.42	58.49	43.68	73
74	59.87	43.50	59.68	43.76	59.49	44.02	59.29	44.28	74
75	60.68	44.08	60.48	44.35	60.29	44.61	60.09	44.87	75
76	61.49	44.67	61.29	44.94	61.09	45.21	60.90	45.47	76
77	62.29	45.26	62.10	45.53	61.90	45.80	61.70	46.07	77
78	63.10	45.85	62.90	46.12	62.70	46.40	62.50	46.67	78
79	63.91	46.43	63.71	46.71	63.50	46.99	63.30	47.27	79
80	64.72	47.02	64.52	47.30	64.31	47.59	64.10	47.87	80
81	65.53	47.61	65.32	47.90	65.11	48.18	64.90	48.46	81
82	66.34	48.20	66.13	48.49	65.92	48.78	65.70	49.06	82
83	67.15	48.79	66.93	49.08	66.72	49.37	66.50	49.66	83
84	67.96	49.37	67.74	49.67	67.52	49.97	67.31	50.26	84
85	68.77	49.96	68.55	50.26	68.33	50.56	68.11	50.86	85
86	69.58	50.55	69.35	50.85	69.13	51.15	68.91	51.46	86
87	70.38	51.14	70.16	51.44	69.94	51.75	69.71	52.05	87
88	71.19	51.73	70.97	52.04	70.74	52.34	70.51	52.65	88
89	72.00	52.31	71.77	52.63	71.54	52.94	71.31	53.25	89
90	72.81	52.90	72.58	53.22	72.35	53.53	72.11	53.85	90
91	73.62	53.49	73.39	53.81	73.15	54.13	72.91	54.45	91
92	74.43	54.08	74.19	54.40	73.95	54.72	73.72	55.05	92
93	75.24	54.66	75.00	54.99	74.76	55.32	74.52	55.64	93
94	76.05	55.25	75.81	55.58	75.56	55.91	75.32	56.24	94
95	76.86	55.84	76.61	56.17	76.37	56.51	76.12	56.84	95
96	77.67	56.43	77.42	56.77	77.17	57.10	76.92	57.44	96
97	78.47	57.02	78.23	57.36	77.97	57.70	77.72	58.04	97
98	79.28	57.60	79.03	57.95	78.78	58.29	78.52	58.64	98
99	80.09	58.19	79.84	58.54	79.58	58.89	79.32	59.23	99
100	80.90	58.78	80.64	59.13	80.39	59.48	80.13	59.83	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	54 Deg.		53¾ Deg.		53½ Deg.		53¼ Deg.		

Distance.	37 Deg.		37¼ Deg.		37½ Deg.		37¾ Deg.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep
1	0.80	0.60	0.80	0.61	0.79	0.61	0.79	0.
2	1.60	1.20	1.59	1.21	1.59	1.22	1.58	1.
3	2.40	1.81	2.39	1.82	2.38	1.83	2.37	1.
4	3.19	2.41	3.18	2.42	3.17	2.43	3.16	2.
5	3.99	3.01	3.98	3.03	3.97	3.04	3.95	3.
6	4.79	3.61	4.78	3.63	4.76	3.65	4.74	3.
7	5.59	4.21	5.57	4.24	5.55	4.26	5.53	4.
8	6.39	4.81	6.37	4.84	6.35	4.87	6.33	4.
9	7.19	5.42	7.16	5.45	7.14	5.48	7.12	5.
10	7.99	6.02	7.96	6.05	7.93	6.09	7.91	6.
11	8.78	6.62	8.76	6.66	8.73	6.70	8.70	6.
12	9.58	7.22	9.55	7.26	9.52	7.31	9.49	7.
13	10.38	7.82	10.35	7.87	10.31	7.91	10.28	7.
14	11.18	8.43	11.14	8.47	11.11	8.52	11.07	8.
15	11.98	9.03	11.94	9.08	11.90	9.13	11.86	9.
16	12.78	9.63	12.74	9.68	12.69	9.74	12.65	9.
17	13.58	10.23	13.53	10.29	13.49	10.35	13.44	10.
18	14.38	10.83	14.33	10.90	14.28	10.96	14.23	11.
19	15.17	11.43	15.12	11.50	15.07	11.57	15.02	11.
20	15.97	12.04	15.92	12.11	15.87	12.18	15.81	12.
21	16.77	12.64	16.72	12.71	16.66	12.78	16.60	12.
22	17.57	13.24	17.51	13.32	17.45	13.39	17.40	13.
23	18.37	13.84	18.31	13.92	18.25	14.00	18.19	14.
24	19.17	14.44	19.10	14.53	19.04	14.61	18.98	14.
25	19 97	15.05	19.90	15.13	19.83	15.22	19.77	15.
26	20.76	15.65	20.70	15.74	20.63	15.83	20.56	15.
27	21.56	16.25	21.49	16.34	21.42	16.44	21.35	16.
28	22.36	16.85	22.29	16.95	22.21	17.05	22.14	17.
29	23.16	17.45	23.08	17.55	23.01	17.65	22.93	17.
30	23.96	18.05	23.88	18.16	23.80	18.26	23.72	18.
31	24.76	18.66	24.68	18.76	24.59	18.87	24.51	18.
32	25.56	19.26	25.47	19.37	25.39	19.48	25.30	19.
33	26.35	19.86	26.27	19.97	26.18	20.09	26.09	20.
34	27.15	20.46	27.06	20.58	26.97	20.70	26.88	20.
35	27.95	21.06	27.86	21.19	27.77	21.31	27.67	21.
36	28.75	21.67	28.66	21.79	28.56	21.92	28.46	22.
37	29.55	22.27	29.45	22.40	29.35	22.52	29.26	22.
38	30.35	22.87	30.25	23.00	30.15	23.13	30.05	23.
39	31.15	23.47	31.04	23.61	30.94	23.74	30.84	23.
40	31.95	24.07	31.84	24.21	31.73	24.35	31.63	24.
41	32.74	24.67	32.64	24.82	32.53	24.96	32.42	25.
42	33.54	25.28	33.43	25.42	33.32	25.57	33.21	25.
43	34.34	25.88	34.23	26.03	34.11	26.18	34.00	26.
44	35.14	26.48	35.02	26.63	34.91	26.79	34.79	26.
45	35.94	27.08	35.82	27.24	35.70	27.39	35.58	27.
46	36.74	27.68	36.62	27.84	36.49	28.00	36.37	28.
47	37.54	28.29	37.41	28.45	37.29	28.61	37.16	28.
48	38.33	28.89	38.21	29.05	38.08	29.22	37.95	29.
49	39.13	29.49	39.00	29.66	38.87	29.83	38.74	30.
50	39.93	30.09	39.80	30.26	39.67	30.44	39.53	30.
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	La
	53 Deg.		52¾ Deg.		52½ Deg.		52¼ Deg.	

Distance.	37 Deg.		37¼ Deg.		37½ Deg.		37¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	40.73	30.69	40.60	30.87	40.46	31.05	40.33	31.22	51
52	41.53	31.29	41.39	31.48	41.25	31.66	41.12	31.84	52
53	42.33	31.90	42.19	32.08	42.05	32.26	41.91	32.45	53
54	43.13	32.50	42.98	32.69	42.84	32.87	42.70	33.06	54
55	43.92	33.10	43.78	33.29	43.63	33.48	43.49	33.67	55
56	44.72	33.70	44.58	33.90	44.43	34.09	44.28	34.28	56
57	45.52	34.30	45.37	34.50	45.22	34.70	45.07	34.90	57
58	46.32	34.91	46.17	35.11	46.01	35.31	45.86	35.51	58
59	47.12	35.51	46.96	35.71	46.81	35.92	46.65	36.12	59
60	47.92	36.11	47.76	36.32	47.60	36.53	47.44	36.73	60
61	48.72	36.71	48.56	36.92	48.39	37.13	48.23	37.35	61
62	49.52	37.31	49.35	37.53	49.19	37.74	49.02	37.96	62
63	50.31	37.91	50.15	38.13	49.98	38.35	49.81	38.57	63
64	51.11	38.52	50.94	38.74	50.77	38.96	50.60	39.18	64
65	51.91	39.12	51.74	39.34	51.57	39,57	51.39	39.79	65
66	52.71	39.72	52.54	39.95	52.36	40.18	52.19	40.41	66
67	53.51	40.32	53.33	40.55	53.15	40.79	52.98	41.02	67
68	54.31	40.92	54.13	41.16	53.95	41.40	53.77	41.63	68
69	55.11	41.53	54.92	41.77	54.74	42.00	54.56	42.24	69
70	55.90	42.13	55.72	42.37	55.53	42.61	55.35	42.86	70
71	56.70	42.73	56.52	42.98	56.33	43.22	56.14	43.47	71
72	57.50	43.33	57.31	43.58	57.12	43.83	56.93	44.08	72
73	58.30	43.93	58.11	44.19	57.91	44.44	57.72	44.69	73
74	59.10	44.53	58.90	44.79	58.71	45.05	58.51	45.30	74
75	59.90	45.14	59.70	45.40	59.50	45.66	59.30	45.92	75
76	60.70	45.74	60.50	46.00	60.29	46.27	60.09	46.53	76
77	61.49	46.34	61.29	46.61	61.09	46.87	60.88	47.14	77
78	62.29	46.94	62.09	47.21	61.88	47.48	61.67	47.75	78
79	63.09	47.54	62.88	47.82	62.67	48.09	62.46	48.37	79
80	63.89	48.15	63.68	48.42	63.47	48.70	63.26	48.98	80
81	64.69	48.75	64.48	49.03	64.26	49.31	64.05	49.59	81
82	65.49	49.35	65.27	49.63	65.05	49.92	64.84	50.20	82
83	66.29	49.95	66.07	50.24	65.85	50.53	65.63	50.81	83
84	67.09	50.55	66.86	50.84	66.64	51.14	66.42	51.43	84
85	67.88	51.15	67.66	51.45	67.43	51.74	67.21	52.04	85
86	68.68	51.76	68.46	52.06	68.23	52.35	68.00	52.65	86
87	69.48	52.36	69.25	52.66	69.02	52.96	68.79	53.26	87
88	70.28	52.96	70.05	53.27	69.82	53.57	69.58	53.88	88
89	71.08	53.56	70.84	53.87	70.61	54.18	70.37	54.49	89
90	71.88	54.16	71.64	54.48	71.40	54.79	71.16	55.10	90
91	72.68	54.77	72.44	55.08	72.20	55.40	71.95	55.71	91
92	73.47	55.37	73.23	55.69	72.99	56.01	72.74	56.32	92
93	74.27	55.97	74.03	56.29	73.78	56.61	73.53	56.94	93
94	75.07	56.57	74.82	56.90	74.58	57.22	74.32	57.55	94
95	75.87	57.17	75.62	57.50	75.37	57.83	75.12	58.16	95
96	76.67	57.77	76.42	58.11	76.16	58.44	75.91	58.77	96
97	77.47	58.38	77.21	58.71	76.96	59.05	76.70	59.39	97
98	78.27	58.98	78.01	59.32	77.75	59.66	77.49	60.00	98
99	79.06	59.58	78.80	59.92	78.54	60.27	78.28	60.61	99
100	79.86	60.18	79.60	60.53	79.34	60.88	79.07	61.22	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	53 Deg.		52¾ Deg.		52½ Deg.		52¼ Deg.		

Distance.	38 Deg.		38¼ Deg.		38½ Deg.		38¾ Deg	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	D
1	0.79	0.62	0.79	0.62	0.78	0.62	0.78	0
2	[illegible]	1.23	1.57	1.24	1.57	1.24	1.56	1
3	[illegible]	1.85	2.36	1.86	2.35	1.87	2.34	1
4	3.15	2.46	3.14	2.48	3.13	2.49	3.12	2
5	3.94	3.08	3.93	3.10	3.91	3.11	3.90	3
6	4.73	3.69	4.71	3.71	4.70	3.74	4.68	3
7	5.52	4.31	5.50	4.33	5.48	4.36	5.46	4
8	6.30	4.93	6.28	4.95	6.26	4.98	6.24	5
9	7.09	5.54	7.07	5.57	7.04	5.60	7.02	5
10	7.88	6.16	7.85	6.19	7.83	6.23	7.80	6
11	8.67	6.77	8.64	6.81	8.61	6.85	8.58	6
12	9.46	7.39	9.42	7.43	9.39	7.47	9.36	7
13	10.24	8.00	10.21	8.05	10.17	8.09	10.14	8
14	11.03	8.62	10.99	8.67	10.96	8.72	10.92	8
15	11.82	9.23	11.78	9.29	11.74	9.34	11.70	9
16	12.61	9.85	12.57	9.91	12.52	9.96	12.48	10
17	13.40	10.47	13.35	10.52	13.30	10.58	13.26	10
18	14.18	11.08	14.14	11.14	14.09	11.21	14.04	11
19	14.97	11.70	14.92	11.76	14.87	11.83	14.82	11
20	15.76	12.31	15.71	12.38	15.65	12.45	15.60	12
21	16.55	12.93	16.49	13.00	16.43	13.07	16.38	13
22	17.34	13.54	17.28	13.62	17.22	13.70	17.16	13
23	18.12	14.16	18.06	14.24	18.00	14.32	17.94	14
24	18.91	14.78	18.85	14.86	18.78	14.94	18.72	15
25	19.70	15.39	19.63	15.48	19.57	15.56	19.50	15
26	20.49	16.01	20.42	16.10	20.35	16.19	20.28	16
27	21.28	16.62	21.20	16.72	21.13	16.81	21.06	16
28	22.06	17.24	21.99	17.33	21.91	17.43	21.84	17
29	22.85	17.85	22.77	17.95	22.70	18.05	22.62	18
30	23.64	18.47	23.56	18.57	23.48	18.68	23.40	18
31	24.43	19.09	24.34	19.19	24.26	19.30	24.18	19
32	25.22	19.70	25.13	19.81	25.04	19.92	24.96	20
33	26.00	20.32	25.92	20.43	25.83	20.54	25.74	20
34	26.79	20.93	26.70	21.05	26.61	21.17	26.52	21
35	27.58	21.55	27.49	21.67	27.39	21.79	27.30	21
36	28.37	22.16	28.27	22.29	28.17	22.41	28.08	22
37	29.16	22.78	29.06	22.91	28.96	23.03	28.86	23
38	29.94	23.40	29.84	23.53	29.74	23.66	29.64	23
39	30.73	24.01	30.63	24.14	30.52	24.28	30.42	24
40	31.52	24.63	31.41	24.76	31.30	24.90	31.20	25
41	32.31	25.24	32.20	25.38	32.09	25.52	31.98	25
42	33.10	25.86	32.98	26.00	32.87	26.15	32.76	26
43	33.88	26.47	33.77	26.62	33.65	26.77	33.53	26
44	34.67	27.09	34.55	27.24	34.43	27.39	34.31	27
45	35.46	27.70	35.34	27.86	35.22	28.01	35.09	28
46	36.25	28.32	36.12	28.48	36.00	28.64	35.87	28
47	37.04	28.94	36.91	29.10	36.78	29.26	36 65	29
48	37.82	29.55	37.70	29.72	37.57	29.88	37.43	30
49	38.61	30.17	38.48	30.34	38.35	30.50	38.21	30
50	39.40	30.78	39.27	30.95	39.13	31.13	38.99	31
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	L
	52 Deg.		51¾ Deg.		51½ Deg.		51¼ Deg	

Distance.	38 Deg.		38¼ Deg.		38½ Deg.		38¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	40.19	31.40	40.05	31.57	39.91	31.75	39.77	31.92	51
52	40.98	32.01	40.84	32.19	40.70	32.37	40.55	32.55	52
53	41.76	32.63	41.62	32.81	41.48	32.99	41.33	33.17	53
54	42.55	33.25	42.41	33.43	42.26	33.62	42.11	33.80	54
55	43.34	33.86	43.19	34.05	43.04	34.24	42.89	34.43	55
56	44.13	34.48	43.98	34.67	43.83	34.86	43.67	35.05	56
57	44.92	35.09	44.76	35.29	44.61	35.48	44.45	35.68	57
58	45.70	35.71	45.55	35.91	45.39	36.11	45.23	36.30	58
59	46.49	36.32	46.33	36.53	46.17	36.73	46.01	36.93	59
60	47.28	36.94	47.12	37.15	46.96	37.35	46.79	37.56	60
61	48.07	37.56	47.90	37.76	47.74	37.97	47.57	38.18	61
62	48.86	38.17	48.69	38.38	48.52	38.60	48.35	38.81	62
63	49.64	38.79	49.47	39.00	49.30	39.22	49.13	39.43	63
64	50.43	39.40	50.26	39.62	50.09	39.84	49.91	40.06	64
65	51.22	40.02	51.05	40.24	50.87	40.46	50.69	40.68	65
66	52.01	40.63	51.83	40.86	51.65	41.09	51.47	41.31	66
67	52.80	41.25	52.62	41.48	52.43	41.71	52.25	41.94	67
68	53.58	41.86	53.40	42.10	53.22	42.33	53.03	42.56	68
69	54.37	42.48	54.19	42.72	54.00	42.95	53.81	43.19	69
70	55.16	43.10	54.97	43.34	54.78	43.58	54.59	43.81	70
71	55.95	43.71	55.76	43.96	55.57	44.20	55.37	44.44	71
72	56.74	44.33	56.54	44 57	56.35	44.82	56.15	45.07	72
73	57.52	44.94	57.33	45.19	57.13	45.44	56.93	45.69	73
74	58.31	45.56	58.11	45.81	57.91	46.07	57.71	46.32	74
75	59.10	46.17	58.90	46.43	58.70	46.69	58.49	46.94	75
76	59.89	46.79	59.68	47.05	59.48	47.31	59.27	47.57	76
77	60.68	47.41	60.47	47.67	60.26	47.93	60.05	48.20	77
78	61.46	48.02	61.25	48.29	61.04	48.56	60.83	48.82	78
79	62.25	48.64	62.04	48.91	61.83	49.18	61.61	49.45	79
80	63.04	49.25	62.83	49.53	62.61	49.80	62.39	50.07	80
81	63.83	49.87	63.61	50.15	63.39	50.42	63.17	50.70	81
82	64.62	50.48	64.40	50.77	64.17	51.05	63.95	51.33	82
83	65.40	51.10	65.18	51.38	64.96	51.67	64.73	51.95	83
84	66.19	51.72	65.97	52.00	65.74	52.29	65.51	52.58	84
85	66.98	52.33	66.75	52.62	66.52	52.91	66.29	53.20	85
86	67.77	52.95	67.54	53.24	67.30	53.54	67.07	53.83	86
87	68.56	53.56	68.32	53.86	68.09	54.16	67.85	54.46	87
88	69.34	54.18	69.11	54.48	68.87	54.78	68.63	55.08	88
89	70.13	54.79	69.89	55.10	69.65	55.40	69.41	55.71	89
90	70.92	55.41	70.68	55.72	70.43	56.03	70.19	56.33	90
91	71.71	56.03	71.46	56.34	71.22	56.65	70.97	56.96	91
92	72.50	56.64	72.25	56.96	72.00	57.27	71.75	57.58	92
93	73.28	57.26	73.03	57.58	72.78	57.89	72.53	58.21	93
94	74.07	57.87	73.82	58.19	73.57	58.52	73.31	58.84	94
95	74.86	58.49	74.61	58.81	74.35	59.14	74.09	59.46	95
96	75.65	59.10	75.39	59.43	75.13	59.76	74.87	60.09	96
97	76.44	59.72	76.18	60.05	75.91	60.38	75.65	60.71	97
98	77.22	60.33	76.96	60.67	76.70	61.01	76.43	61.34	98
99	78.01	60.95	77.75	61.29	77.48	61.63	77.21	61.97	99
100	78.80	61.57	78.53	61.91	78.26	62.25	77.99	62.59	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	52 Deg.		51¾ Deg.		51½ Deg.		51¼ Deg.		

Distance.	39 Deg.		39¼ Deg.		39½ Deg.		39¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.78	0.63	0.77	0.63	0.77	0.64	0.77	0.64	1
2	1.55	1.26	1.55	1.27	1.54	1.27	1.54	1.28	2
3	2.33	1.89	2.32	1.90	2.31	1.91	2.31	1.92	3
4	3.11	2.52	3.10	2.53	3.09	2.54	3.08	2.56	4
5	3.89	3.15	3.87	3.16	3.86	3.18	3.84	3.20	5
6	4.66	3.78	4.65	3.80	4.63	3.82	4.61	3.84	6
7	5.44	4.41	5.42	4.43	5.40	4.45	5.38	4.48	7
8	6.22	5.03	6.20	5.06	6.17	5.09	6.15	5.12	8
9	6.99	5.66	6.97	5.69	6.94	5.72	6.92	5.75	9
10	7.77	6.29	7.74	6.33	7.72	6.36	7.69	6.39	10
11	8.55	6.92	8.52	6.96	8.49	7.00	8.46	7.03	11
12	9.33	7.55	9.29	7.59	9.26	7.63	9.23	7.67	12
13	10.10	8.18	10.07	8.23	10.03	8.27	9.99	8.31	13
14	10.88	8.81	10.84	8.86	10.80	8.91	10.76	8.95	14
15	11.66	9.44	11.62	9.49	11.57	9.54	11.53	9.59	15
16	12.43	10.07	12.39	10.12	12.35	10.18	12.30	10.23	16
17	13.21	10.70	13.16	10.76	13.12	10.81	13.07	10.87	17
18	13.99	11.33	13.94	11.39	13.89	11.45	13.84	11.51	18
19	14.77	11.96	14.71	12.02	14.66	12.09	14.61	12.15	19
20	15.54	12.59	15.49	12.65	15.43	12.72	15.38	12.79	20
21	16.32	13.22	16.26	13.29	16.20	13.36	16.15	13.43	21
22	17.10	13.84	17.04	13.92	16.98	13.99	16.91	14.07	22
23	17.87	14.47	17.81	14.55	17.75	14.63	17.68	14.71	23
24	18.65	15.10	18.59	15.18	18.52	15.27	18.45	15.35	24
25	19.43	15.73	19.36	15.82	19.29	15.90	19.22	15.99	25
26	20.21	16.36	20.13	16.45	20.06	16.54	19.99	16.63	26
27	20.98	16.99	20.91	17.08	20.83	17.17	20.76	17.26	27
28	21.76	17.62	21.68	17.72	21.61	17.81	21.53	17.90	28
29	22.54	18.25	22.46	18.35	22.38	18.45	22.30	18.54	29
30	23.31	18.88	23.23	18.98	23.15	19.08	23.07	19.18	30
31	24.09	19.51	24.01	19.61	23.92	19.72	23.83	19.82	31
32	24.87	20.14	24.78	20.25	24.69	20.35	24.60	20.46	32
33	25.65	20.77	25.55	20.88	25.46	20.99	25.37	21.10	33
34	26.42	21.40	26.33	21.51	26.24	21.63	26.14	21.74	34
35	27.20	22.03	27.10	22.14	27.01	22.26	26.91	22.38	35
36	27.98	22.66	27.88	22.78	27.78	22.90	27.68	23.02	36
37	28.75	23.28	28.65	23.41	28.55	23.53	28.45	23.66	37
38	29.53	23.91	29.43	24.04	29.32	24.17	29.22	24.30	38
39	30.31	24.54	30.20	24.68	30.09	24.81	29.98	24.94	39
40	31.09	25.17	30.98	25.31	30.86	25.44	30.75	25.58	40
41	31.86	25.80	31.75	25.94	31.64	26.08	31.52	26.22	41
42	32.64	26.43	32.52	26.57	32.41	26.72	32.29	26.86	42
43	33.42	27.06	33.30	27.21	33.18	27.35	33.06	27.50	43
44	34.19	27.69	34.07	27.84	33.95	27.99	33.83	28.14	44
45	34.97	28.32	34.85	28.47	34.72	28.62	34.60	28.77	45
46	35.75	28.95	35.62	29.10	35.49	29.26	35.37	29.41	46
47	36.53	29.58	36.40	29.74	36.27	29.90	36.14	30.05	47
48	37.30	30.21	37.17	30.37	37.04	30.53	36.90	30.69	48
49	38.08	30.84	37.95	31.00	37.81	31.17	37.67	31.33	49
50	38.86	31.47	38.72	31.64	38.58	31.80	38.44	31.97	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	51 Deg.		50¾ Deg.		50½ Deg.		50¼ Deg.		

Distance.	39 Deg.		39¼ Deg.		39½ Deg.		39¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	39.63	32.10	39.49	32.27	39.35	32.44	39.21	32.61	51
52	40.41	32.72	40.27	32.90	40.12	33.08	39.98	33.25	52
53	41.19	33.35	41.04	33.53	40.90	33.71	40.75	33.89	53
54	41.97	33.98	41.82	34.17	41.67	34.35	41.52	34.53	54
55	42.74	34.61	42.59	34.80	42.44	34.98	42.29	35.17	55
56	43.52	35.24	43.37	35.43	43.21	35.62	43.06	35.81	56
57	44.30	35.87	44.14	36.06	43.98	36.26	43.82	36.45	57
58	45.07	36.50	44.91	36.70	44.75	36.89	44.59	37.09	58
59	45.85	37.13	45.69	37.33	45.53	37.53	45.36	37.73	59
60	46.63	37.76	46.46	37.96	46.30	38.16	46.13	38.37	60
61	47.41	38.39	47.24	38.60	47.07	38.80	46.90	39.01	61
62	48.18	39.02	48.01	39.23	47.84	39.44	47.67	39.65	62
63	48.96	39.65	48.79	39.86	48.61	40.07	48.44	40.28	63
64	49.74	40.28	49.56	40.49	49.38	40.71	49.21	40.92	64
65	50.51	40.91	50.34	41.13	50.16	41.35	49.97	41.56	65
66	51.29	41.54	51.11	41.76	50.93	41.98	50.74	42.20	66
67	52.07	42.16	51.88	42.39	51.70	42.62	51.51	42.84	67
68	52.85	42.79	52.66	43.02	52.47	43.25	52.28	43.48	68
69	53.52	43.42	53.43	43.66	53.24	43.89	53.05	44.12	69
70	54.40	44.05	54.21	44.29	54.01	44.53	53.82	44.76	70
71	55.18	44.68	54.98	44.92	54.79	45.16	54.59	45.40	71
72	55.95	45.31	55.76	45.55	55.56	45.80	55.36	46.04	72
73	56.73	45.94	56.53	46.19	56.33	46.43	56.13	46.68	73
74	57.51	46.57	57.31	46.82	57.10	47.07	56.89	47.32	74
75	58.29	47.20	58.08	47.45	57.87	47.71	57.66	47.96	75
76	59.06	47.83	58.85	48.09	58.64	48.34	58.43	48.60	76
77	59.84	48.46	59.63	48.72	59.42	48.98	59.20	49.24	77
78	60.62	49.09	60.40	49.35	60.19	49.61	59.97	49.88	78
79	61.39	49.72	61.18	49.98	60.96	50.25	60.74	50.52	79
80	62.17	50.35	61.95	50.62	61.73	50.89	61.51	51.16	80
81	62.95	50.97	62.73	51.25	62.50	51.52	62.28	51.79	81
82	63.73	51.60	63.50	51.88	63.27	52.16	63.04	52.43	82
83	64.50	52.23	64.27	52.51	64.04	52.79	63.81	53.07	83
84	65.28	52.86	65.05	53.15	64.82	53.43	64.58	53.71	84
85	66.06	53.49	65.82	53.78	65.59	54.07	65.35	54.35	85
86	66.83	54.12	66.60	54.41	66.36	54.70	66.12	54.99	86
87	67.61	54.75	67.37	55.05	67.13	55.34	66.89	55.63	87
88	68.39	55.38	68.15	55.68	67.90	55.97	67.66	56.27	88
89	69.17	56.01	68.92	56.32	68.67	56.61	68.43	56.91	89
90	69.94	56.64	69.70	56.94	69.45	57.25	69.20	57.55	90
91	70.72	57.27	70.47	57.58	70.22	57.88	69.96	58.19	91
92	71.50	57.90	71.24	58.21	70.99	58.52	70.73	58.83	92
93	72.27	58.53	72.02	58.84	71.76	59.16	71.50	59.47	93
94	73.05	59.16	72.79	59.47	72.53	59.79	72.27	60.11	94
95	73.83	59.79	73.57	60.11	73.30	60.43	73.04	60.75	95
96	74.61	60.41	74.34	60.74	74.08	61.06	73.81	61.39	96
97	75.38	61.04	75.12	61.37	74.85	61.70	74.58	62.03	97
98	76.16	61.67	75.89	62.01	75.62	62.34	75.35	62.66	98
99	76.94	62.30	76.66	62.64	76.39	62.97	76.12	63.30	99
100	77.71	62.93	77.44	63.27	77.16	63.61	76.88	63.94	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	51 Deg.		50¾ Deg.		50½ Deg.		50¼ Deg.		

Distance.	40 Deg.		40¼ Deg.		40½ Deg.		40¾ Deg.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	0.77	0.64	0.76	0.65	0.76	0.65	0.76	0.65
2	1.53	1.29	1.53	1.29	1.52	1.30	1.52	1.31
3	2.30	1.93	2.29	1.94	2.28	1.95	2.27	1.96
4	3.06	2.57	3.05	2.58	3.04	2.60	3.03	2.61
5	3.83	3.21	3.82	3.23	3.80	3.25	3.79	3.26
6	4.60	3.86	4.58	3.88	4.56	3.90	4.55	3.92
7	5.36	4.50	5.34	4.52	5.32	4.55	5.30	4.57
8	6.13	5.14	6.11	5.17	6.08	5.20	6.06	5.22
9	6.89	5.79	6.87	5.82	6.84	5.84	6.82	5.87
10	7.66	6.43	7.63	6.46	7.60	6.49	7.58	6.53
11	8.43	7.07	8.40	7.11	8.36	7.14	8.33	7.18
12	9.19	7.71	9.16	7.75	9.12	7.79	9.09	7.83
13	9.96	8.36	9.92	8.40	9.89	8.44	9.85	8.49
14	10.72	9.00	10.69	9.05	10.65	9.09	10.61	9.14
15	11.49	9.64	11.45	9.69	11.41	9.74	11.36	9.79
16	12.26	10.28	12.21	10.34	12.17	10.39	12.12	10.44
17	13.02	10.93	12.97	10.98	12.93	11.04	12.88	11.10
18	13.79	11.57	13.74	11.63	13.69	11.69	13.64	11.75
19	14.55	12.21	14.50	12.28	14.45	12.34	14.39	12.40
20	15.32	12.86	15.26	12.92	15.21	12.99	15.15	13.06
21	16.09	13.50	16.03	13.57	15.97	13.64	15.91	13.71
22	16.85	14.14	16.79	14.21	16.73	14.29	16.67	14.36
23	17.62	14.78	17.55	14.86	17.49	14.94	17.42	15.01
24	18.39	15.43	18.32	15.51	18.25	15.59	18.18	15.67
25	19.15	16.07	19.08	16.15	19.01	16.24	18.94	16.32
26	19.92	16.71	19.84	16.80	19.77	16.89	19.70	16.97
27	20.68	17.36	20.61	17.45	20.53	17.54	20.45	17.62
28	21.45	18.00	21.37	18.09	21.29	18.18	21.21	18.28
29	22.22	18.64	22.13	18.74	22.05	18.83	21.97	18.93
30	22.98	19.28	22.90	19.38	22.81	19.48	22.73	19.58
31	23.75	19.93	23.66	20.03	23.57	20.13	23.48	20.24
32	24.51	20.57	24.42	20.68	24.33	20.78	24.24	20.89
33	25.28	21.21	25.19	21.32	25.09	21.43	25.00	21.54
34	26.05	21.85	25.95	21.97	25.85	22.08	25.76	22.19
35	26.81	22.50	26.71	22.61	26.61	22.73	26.51	22.85
36	27.58	23.14	27.48	23.26	27.37	23.38	27.27	23.50
37	28.34	23.78	28.24	23.91	28.13	24.03	28.03	24.15
38	29.11	24.43	29.00	24.55	28.90	24.68	28.79	24.80
39	29.88	25.07	29.77	25.20	29.66	25.33	29.54	25.46
40	30.64	25.71	30.53	25.84	30.42	25.98	30.30	26.11
41	31.41	26.35	31.29	26.49	31.18	26.63	31.06	26.76
42	32.17	27.00	32.06	27.14	31.94	27.28	31.82	27.42
43	32.94	27.64	32.82	27.78	32.70	27.93	32.58	28.07
44	33.71	28.28	33.58	28.43	33.46	28.58	33.33	28.72
45	34.47	28.93	34.35	29.08	34.22	29.23	34.09	29.37
46	35.24	29.57	35.11	29.72	34.98	29.87	34.85	30.03
47	36.00	30.21	35.87	30.37	35.74	30.52	35.61	30.68
48	36.77	30.85	36.64	31.01	36.50	31.17	36.36	31.33
49	37.54	31.50	37.40	31.66	37.26	31.82	37.12	31.99
50	38.30	32.14	38.16	32.31	38.02	32.47	37.88	32.64
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	50 Deg.		49¾ Deg.		49½ Deg.		49¼ Deg.	

Distance.	40 Deg.		40¼ Deg.		40½ Deg.		40¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	39.07	32.78	38.92	32.95	38.78	33.12	38.64	33.29	51
52	39.83	33.42	39.69	33.60	39.54	33.77	39.39	33.94	52
53	40.60	34.07	40.45	34.24	40.30	34.42	40.15	34.60	53
54	41.37	34.71	41.21	34.89	41.06	35.07	40.91	35.25	54
55	42.13	35.35	41.98	35.54	41.82	35.72	41.67	35.90	55
56	42.90	36.00	42.74	36.18	42.58	36.37	42.42	36.55	56
57	43.66	36.64	43.50	36.83	43.34	37.02	43.18	37.21	57
58	44.43	37.28	44.27	37.48	44.10	37.67	43.94	37.86	58
59	45.20	37.92	45.03	38.12	44.86	38.32	44.70	38.51	59
60	45.96	38.57	45.79	38.77	45.62	38.97	45.45	39.17	60
61	46.73	39.21	46.56	39.41	46.38	39.62	46.21	39.82	61
62	47.49	39.85	47.32	40.06	47.15	40.27	46.97	40.47	62
63	48.26	40.50	48.08	40.71	47.91	40.92	47.73	41.12	63
64	49.03	41.14	48.85	41.35	48.67	41.56	48.48	41.78	64
65	49.79	41.78	49.61	42.00	49.43	42.21	49.24	42.43	65
66	50.56	42.42	50.37	42.64	50.19	42.86	50.00	43.08	66
67	51.32	43.07	51.14	43.29	50.95	43.51	50.76	43.73	67
68	52.09	43.71	51.90	43.94	51.71	44.16	51.51	44.39	68
69	52.86	44.35	52.66	44.58	52.47	44.81	52.27	45.04	69
70	53.62	45.00	53.43	45.23	53.23	45.46	53.03	45.69	70
71	54.39	45.64	54.19	45.87	53.99	46.11	53.79	46.35	71
72	55.16	46.28	54.95	46.52	54.75	46.76	54.54	47.00	72
73	55.92	46.92	55.72	47.17	55.51	47.41	55.30	47.65	73
74	56.69	47.57	56.48	47.81	56.27	48.06	56.06	48.30	74
75	57.45	48.21	57.24	48.46	57.03	48.71	56.82	48.96	75
76	58.22	48.85	58.01	49.11	57.79	49.36	57.57	49.61	76
77	58.99	49.49	58.77	49.75	58.55	50.01	58.33	50.26	77
78	59.75	50.14	59.53	50.40	59.31	50.66	59.09	50.92	78
79	60.52	50.78	60.30	51.04	60.07	51.31	59.85	51.57	79
80	61.28	51.42	61.06	51.69	60.83	51.96	60.61	52.22	80
81	62.05	52.07	61.82	52.34	61.59	52.61	61.36	52.87	81
82	62.82	52.71	62.59	52.98	62.35	53.25	62.12	53.53	82
83	63.58	53.35	63.35	53.63	63.11	53.90	62.88	54.18	83
84	64.35	53.99	64.11	54.27	63.87	54.55	63.64	54.83	84
85	65.11	54.64	64.87	54.92	64.63	55.20	64.39	55.48	85
86	65.88	55.28	65.64	55.57	65.39	55.85	65.15	56.14	86
87	66.65	55.92	66.40	56.21	66.16	56.50	65.91	56.79	87
88	67.41	56.57	67.16	56.86	66.92	57.15	66.67	57.44	88
89	68.18	57.21	67.93	57.50	67.68	57.80	67.42	58.10	89
90	68.94	57.85	68.69	58.15	68.44	58.45	68.18	58.75	90
91	69.71	58.49	69.45	58.80	69.20	59.10	68.94	59.40	91
92	70.48	59.14	70.22	59.44	69.96	59.75	69.70	60.05	92
93	71.24	59.78	70.98	60.09	70.72	60.40	70.45	60.71	93
94	72.01	60.42	71.74	60.74	71.48	61.05	71.21	61.36	94
95	72.77	61.06	72.51	61.38	72.24	61.70	71.97	62.01	95
96	73.54	61.71	73.27	62.03	73.00	62.35	72.73	62.66	96
97	74.31	62.35	74.03	62.67	73.76	63.00	73.48	63.32	97
98	75.07	62.99	74.80	63.32	74.52	63.65	74.24	63.97	98
99	75.84	63.64	75.56	63.97	75.28	64.30	75.00	64.62	99
100	76.60	64.28	76.32	64.61	76.04	64.94	75.76	65.28	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	50 Deg.		49¾ Deg.		49½ Deg.		49¼ Deg.		

Distance.	41 Deg.		41¼ Deg.		41½ Deg.		41¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.75	0.66	0.75	0.66	0.75	0.66	0.75	0.67	1
2	1.51	1.31	1.50	1.32	1.50	1.33	1.49	1.33	2
3	2.26	1.97	2.26	1.98	2.25	1.99	2.24	2.00	3
4	3.02	2.62	3.01	2.64	3.00	2.65	2.98	2.66	4
5	3.77	3.28	3.76	3.30	3.74	3.31	3.73	3.33	5
6	4.53	3.94	4.51	3.96	4.49	3.98	4.48	4.00	6
7	5.28	4.59	5.26	4.62	5.24	4.64	5.22	4.66	7
8	6.04	5.25	6.01	5.27	5.99	5.30	5.97	5.33	8
9	6.79	5.90	6.77	5.93	6.74	5.96	6.71	5.99	9
10	7.55	6.56	7.52	6.59	7.49	6.63	7.46	6.66	10
11	8.30	7.22	8.27	7.25	8.24	7.29	8.21	7.32	11
12	9.06	7.87	9.02	7.91	8.99	7.95	8.95	7.99	12
13	9.81	8.53	9.77	8.57	9.74	8.61	9.70	8.66	13
14	10.57	9.18	10.53	9.23	10.49	9.28	10.44	9.32	14
15	11.32	9.84	11.28	9.89	11.23	9.94	11.19	9.99	15
16	12.08	10.50	12.03	10.55	11.98	10.60	11.94	10.65	16
17	12.83	11.15	12.78	11.21	12.73	11.26	12.68	11.32	17
18	13.58	11.81	13.53	11.87	13.48	11.93	13.43	11.99	18
19	14.34	12.47	14.28	12.53	14.23	12.59	14.18	12.65	19
20	15.09	13.12	15.04	13.19	14.98	13.25	14.92	13.32	20
21	15.85	13.78	15.79	13.85	15.73	13.91	15.67	13.98	21
22	16.60	14.43	16.54	14.51	16.48	14.58	16.41	14.65	22
23	17.36	15.09	17.29	15.16	17.23	15.24	17.16	15.32	23
24	18.11	15.75	18.04	15.82	17.97	15.90	17.91	15.98	24
25	18.87	16.40	18.80	16.48	18.72	16.57	18.65	16.65	25
26	19.62	17.06	19.55	17.14	19.47	17.23	19.40	17.31	26
27	20.38	17.71	20.30	17.80	20.22	17.89	20.14	17.98	27
28	21.13	18.37	21.05	18.46	20.97	18.55	20.89	18.64	28
29	21.89	19.03	21.80	19.12	21.72	19.22	21.64	19.31	29
30	22.64	19.68	22.56	19.78	22.47	19.88	22.38	19.98	30
31	23.40	20.34	23.31	20.44	23.22	20.54	23.13	20.64	31
32	24.15	20.99	24.06	21.10	23.97	21.20	23.87	21.31	32
33	24.91	21.65	24.81	21.76	24.72	21.87	24.62	21.97	33
34	25.66	22.31	25.56	22.42	25.46	22.53	25.37	22.64	34
35	26.41	22.96	26.31	23.08	26.21	23.19	26.11	23.31	35
36	27.17	23.62	27.07	23.74	26.96	23.85	26.86	23.97	36
37	27.92	24.27	27.82	24.40	27.71	24.52	27.60	24.64	37
38	28.68	24.93	28.57	25.06	28.46	25.18	28.35	25.30	38
39	29.43	25.59	29.32	25.71	29.21	25.84	29.10	25.97	39
40	30.19	26.24	30.07	26.37	29.96	26.50	29.84	26.64	40
41	30.94	26.90	30.83	27.03	30.71	27.17	30.59	27.30	41
42	31.70	27.55	31.58	27.69	31.46	27.83	31.33	27.97	42
43	32.45	28.21	32.33	28.35	32.21	28.49	32.08	28.63	43
44	33.21	28.87	33.08	29.01	32.95	29.16	32.83	29.30	44
45	33.96	29.52	33.83	29.67	33.70	29.82	33.57	29.97	45
46	34.72	30.18	34.58	30.33	34.45	30.48	34.32	30.63	46
47	35.47	30.83	35.34	30.99	35.20	31.14	35.06	31.30	47
48	36.23	31.49	36.09	31.65	35.95	31.81	35.81	31.96	48
49	36.98	32.15	36.84	32.31	36.70	32.47	36.56	32.63	49
50	37.74	32.80	37.59	32.97	37.45	33.13	37.30	33.29	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	49 Deg.		48¾ Deg.		48½ Deg.		48¼ Deg.		

Distance.	41 Deg.		41¼ Deg.		41½ Deg.		41¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	38.49	33.46	38.34	33.63	38.20	33.79	38.05	33.96	51
52	39.24	34.12	39.10	34.29	38.95	34.46	38.79	34.63	52
53	40.00	34.77	39.85	34.95	39.69	35.12	39.54	35.29	53
54	40.75	35.43	40.60	35.60	40.44	35.78	40.29	35.96	54
55	41.51	36.08	41.35	36.26	41.19	36.44	41.03	36.62	55
56	42.26	36.74	42.10	36.92	41.94	37.11	41.78	37.29	56
57	43.02	37.40	42.85	37.58	42.69	37.77	42.53	37.96	57
58	43.77	38.05	43.61	38.24	43.44	38.43	43.27	38.62	58
59	44.53	38.71	44.36	38.90	44.19	39.09	44.02	39.29	59
60	45.28	39.36	45.11	39.56	44.94	39.76	44.76	39.95	60
61	46.04	40.02	45.86	40.22	45.69	40.42	45.51	40.62	61
62	46.79	40.68	46.61	40.88	46.44	41.08	46.26	41.28	62
63	47.55	41.33	47.37	41.54	47.18	41.75	47.00	41.95	63
64	48.30	41.99	48.12	42.20	47.93	42.41	47.75	42.62	64
65	49.06	42.64	48.87	42.86	48.68	43.07	48.49	43.28	65
66	49.81	43.30	49.62	43.52	49.43	43.73	49.24	43.95	66
67	50.57	43.96	50.37	44.18	50.18	44.40	49.99	44.61	67
68	51.32	44.61	51.13	44.84	50.93	45.06	50.73	45.28	68
69	52.07	45.27	51.88	45.49	51.68	45.72	51.48	45.95	69
70	52.83	45.92	52.63	46.15	52.43	46.38	52.22	46.61	70
71	53.58	46.58	53.38	46.81	53.18	47.05	52.97	47.28	71
72	54.34	47.24	54.13	47.47	53.92	47.71	53.72	47.94	72
73	55.09	47.89	54.88	48.13	54.67	48.37	54.46	48.61	73
74	55.85	48.55	55.64	48.79	55.42	49.03	55.21	49.28	74
75	56.60	49.20	56.39	49.45	56.17	49.70	55.95	49.94	75
76	57.36	49.86	57.14	50.11	56.92	50.36	56.70	50.61	76
77	58.11	50.52	57.89	50.77	57.67	51.02	57.45	51.27	77
78	58.87	51.17	58.64	51.43	58.42	51.68	58.19	51.94	78
79	59.62	51.83	59.40	52.09	59.17	52.35	58.94	52.60	79
80	60.38	52.48	60.15	52.75	59.92	53.01	59.68	53.27	80
81	61.13	53.14	60.90	53.41	60.67	53.67	60.43	53.94	81
82	61.89	53.80	61.65	54.07	61.41	54.33	61.18	54.60	82
83	62.64	54.45	62.40	54.73	62.16	55.00	61.92	55.27	83
84	63.40	55.11	63.15	55.38	62.91	55.66	62.67	55.93	84
85	64.15	55.76	63.91	56.04	63.66	56.32	63.41	56.60	85
86	64.90	56.42	64.66	56.70	64.41	56.99	64.16	57.27	86
87	65.66	57.08	65.41	57.36	65.16	57.65	64.91	57.93	87
88	66.41	57.73	66.16	58.02	65.91	58.31	65.65	58.60	88
89	67.17	58.39	66.91	58.68	66.66	58.97	66.40	59.26	89
90	67.92	59.05	67.67	59.34	67.41	59.64	67.15	59.93	90
91	68.68	59.70	68.42	60.00	68.15	60.30	67.89	60.60	91
92	69.43	60.36	69.17	60.66	68.90	60.96	68.64	61.26	92
93	70.19	61.01	69.92	61.32	69.65	61.62	69.38	61.93	93
94	70.94	61.67	70.67	61.98	70.40	62.29	70.13	62.59	94
95	71.70	62.33	71.43	62.64	71.15	62.95	70.88	63.26	95
96	72.45	62.98	72.18	63.30	71.90	63.61	71.62	63.92	96
97	73.21	63.64	72.93	63.96	72.65	64.27	72.37	64.59	97
98	73.96	64.29	73.68	64.62	73.40	64.94	73.11	65.26	98
99	74.72	64.95	74.43	65.28	74.15	65.60	73.86	65.92	99
100	75.47	65.61	75.18	65.93	74.90	66.26	74.61	66.59	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	49 Deg.		48¾ Deg.		48½ Deg.		48¼ Deg.		

Distance.	42 Deg.		42¼ Deg.		42½ Deg.		42¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.74	0.67	0.74	0.67	0.74	0.68	0.73	0.68	1
2	1.49	1.34	1.48	1.34	1.47	1.35	1.47	1.36	2
3	2.23	2.01	2.22	2.02	2.21	2.03	2.20	2.04	3
4	2.97	2.68	2.96	2.69	2.95	2.70	2.94	2.72	4
5	3.72	3.35	3.70	3.36	3.69	3.38	3.67	3.39	5
6	4.46	4.01	4.44	4.03	4.42	4.05	4.41	4.07	6
7	5.20	4.68	5.18	4.71	5.16	4.73	5.14	4.75	7
8	5.95	5.35	5.92	5.38	5.90	5.40	5.87	5.43	8
9	6.69	6.02	6.66	6.05	6.64	6.08	6.61	6.11	9
10	7.43	6.69	7.40	6.72	7.37	6.76	7.34	6.79	10
11	8.17	7.36	8.14	7.40	8.11	7.43	8.08	7.47	11
12	8.92	8.03	8.88	8.07	8.85	8.11	8.81	8.15	12
13	9.66	8.70	9.62	8.74	9.58	8.78	9.55	8.82	13
14	10.40	9.37	10.36	9.41	10.32	9.46	10.28	9.50	14
15	11.15	10.04	11.10	10.09	11.06	10.13	11.01	10.18	15
16	11.89	10.71	11.84	10.76	11.80	10.81	11.75	10.86	16
17	12.63	11.38	12.58	11.43	12.53	11.48	12.48	11.54	17
18	13.38	12.04	13.32	12.10	13.27	12.16	13.22	12.22	18
19	14.12	12.71	14.06	12.77	14.01	12.84	13.95	12.90	19
20	14.86	13.38	14.80	13.45	14.75	13.51	14.69	13.58	20
21	15.61	14.05	15.54	14.12	15.48	14.19	15.42	14.25	21
22	16.35	14.72	16.28	14.79	16.22	14.86	16.16	14.93	22
23	17.09	15.39	17.02	15.46	16.96	15.54	16.89	15.61	23
24	17.84	16.06	17.77	16.14	17.69	16.21	17.62	16.29	24
25	18.58	16.73	18.51	16.81	18.43	16.89	18.36	16.97	25
26	19.32	17.40	19.25	17.48	19.17	17.57	19.09	17.65	26
27	20.06	18.07	19.99	18.15	19.91	18.24	19.83	18.33	27
28	20.81	18.74	20.73	18.83	20.64	18.92	20.56	19.01	28
29	21.55	19.40	21.47	19.50	21.38	19.59	21.30	19.69	29
30	22.29	20.07	22.21	20.17	22.12	20.27	22.03	20.36	30
31	23.04	20.74	22.95	20.84	22.86	20.94	22.76	21.04	31
32	23.78	21.41	23.69	21.52	23.59	21.62	23.50	21.72	32
33	24.52	22.08	24.43	22.19	24.33	22.29	24.23	22.40	33
34	25.27	22.75	25.17	22.86	25.07	22.97	24.97	23.08	34
35	26.01	23.42	25.91	23.53	25.80	23.65	25.70	23.76	35
36	26.75	24.09	26.65	24.21	26.54	24.32	26.44	24.44	36
37	27.50	24.76	27.39	24.88	27.28	25.00	27.17	25.12	37
38	28.24	25.43	28.13	25.55	28.02	25.67	27.90	25.79	38
39	28.98	26.10	28.87	26.22	28.75	26.35	28.64	26.47	39
40	29.73	26.77	29.61	26.89	29.49	27.02	29.37	27.15	40
41	30.47	27.43	30.35	27.57	30.23	27.70	30.11	27.83	41
42	31.21	28.10	31.09	28.24	30.97	28.37	30.84	28.51	42
43	31.96	28.77	31.83	28.91	31.70	29.05	31.58	29.19	43
44	32.70	29.44	32.57	29.58	32.44	29.73	32.31	29.87	44
45	33.44	30.11	33.31	30.26	33.18	30.40	33.04	30.55	45
46	34.18	30.78	34.05	30.93	33.91	31.08	33.78	31.22	46
47	34.93	31.45	34.79	31.60	34.65	31.75	34.51	31.90	47
48	35.67	32.12	35.53	32.27	35.39	32.43	35.25	32.58	48
49	36.41	32.79	36.27	32.95	36.13	33.10	35.98	33.26	49
50	37.16	33.46	37.01	33.62	36.86	33.78	36.72	33.94	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	48 Deg.		47¾ Deg.		47½ Deg.		47¼ Deg.		

Distance.	42 Deg.		42¼ Deg.		42½ Deg.		42¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	37.90	34.13	37.75	34.29	37.60	34.46	37.45	34.62	51
52	38.64	34.79	38.49	34.96	38.34	35.13	38.18	35.30	52
53	39.39	35.46	39.23	35.64	39.08	35.81	38.92	35.98	53
54	40.13	36.13	39.97	36.31	39.81	36.48	39.65	36.66	54
55	40.87	36.80	40.71	36.98	40.55	37.16	40.39	37.33	55
56	41.62	37.47	41.45	37.65	41.29	37.83	41.12	38.01	56
57	42.36	38.14	42.19	38.32	42.02	38.51	41.86	38.69	57
58	43.10	38.81	42.93	39.00	42.76	39.18	42.59	39.37	58
59	43.85	39.48	43.67	39.67	43.50	39.86	43.32	40.05	59
60	44.59	40.15	44.41	40.34	44.24	40.54	44.06	40.73	60
61	45.33	40.82	45.15	41.01	44.97	41.21	44.79	41.41	61
62	46.07	41.49	45.89	41.69	45.71	41.89	45.53	42.09	62
63	46.82	42.16	46.63	42.36	46.45	42.56	46.26	42.76	63
64	47.56	42.82	47.37	43.03	47.19	43.24	47.00	43.44	64
65	48.30	43.49	48.11	43.70	47.92	43.91	47.73	44.12	65
66	49.05	44.16	48.85	44.38	48.66	44.59	48.47	44.80	66
67	49.79	44.83	49.59	45.05	49.40	45.26	49.20	45.48	67
68	50.53	45.50	50.33	45.72	50.13	45.94	49.93	46.16	68
69	51.28	46.17	51.07	46.39	50.87	46.62	50.67	46.84	69
70	52.02	46.84	51.82	47.07	51.61	47.29	51.40	47.52	70
71	52.76	47.51	52.56	47.74	52.35	47.97	52.14	48.19	71
72	53.51	48.18	53.30	48.41	53.08	48.64	52.87	48.87	72
73	54.25	48.85	54.04	49.08	53.82	49.32	53.61	49.55	73
74	54.99	49.52	54.78	49.76	54.56	49.99	54.34	50.23	74
75	55.74	50.18	55.52	50.43	55.30	50.67	55.07	50.91	75
76	56.48	50.85	56.26	51.10	56.03	51.34	55.81	51.59	76
77	57.22	51.52	57.00	51.77	56.77	52.02	56.54	52.27	77
78	57.97	52.19	57.74	52.44	57.51	52.70	57.28	52.95	78
79	58.71	52.86	58.48	53.12	58.24	53.37	58.01	53.63	79
80	59.45	53.53	59.22	53.79	58.98	54.05	58.75	54.30	80
81	60.19	54.20	59.96	54.46	59.72	54.72	59.48	54.98	81
82	60.94	54.87	60.70	55.13	60.46	55.40	60.21	55.66	82
83	61.68	55.54	61.44	55.81	61.19	56.07	60.95	56.34	83
84	62.42	56.21	62.18	56.48	61.93	56.75	61.68	57.02	84
85	63.17	56.88	62.92	57.15	62.67	57.43	62.42	57.70	85
86	63.91	57.55	63.66	57.82	63.41	58.10	63.15	58.38	86
87	64.65	58.21	64.40	58.50	64.14	58.78	63.89	59.06	87
88	65.40	58.88	65.14	59.17	64.88	59.45	64.62	59.73	88
89	66.14	59.55	65.88	59.84	65.62	60.13	65.35	60.41	89
90	66.88	60.22	66.62	60.51	66.35	60.80	66.09	61.09	90
91	67.63	60.89	67.36	61.19	67.09	61.48	66.82	61.77	91
92	68.37	61.56	68.10	61.86	67.83	62.15	67.56	62.45	92
93	69.11	62.23	68.84	62.53	68.57	62.83	68.29	63.13	93
94	69.86	62.90	69.58	63.20	69.30	63.51	69.03	63.81	94
95	70.60	63.57	70.32	63.87	70.04	64.18	69.76	64.49	95
96	71.34	64.24	71.06	64.55	70.78	64.86	70.49	65.16	96
97	72.08	64.91	71.80	65.22	71.52	65.53	71.23	65.84	97
98	72.83	65.57	72.54	65.89	72.25	66.21	71.96	66.52	98
99	73.57	66.24	73.28	66.56	72.99	66.88	72.70	67.20	99
100	74.31	66.91	74.02	67.24	73.73	67.56	73.43	67.88	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	48 Deg.		47¾ Deg.		47½ Deg.		47¼ Deg.		

Distance.	43 Deg.		43¼ Deg.		43½ Deg.		43¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.73	0.68	0.73	0.69	0.73	0.69	0.72	0.69	1
2	1.46	1.36	1.46	1.37	1.45	1.38	1.44	1.38	2
3	2.19	2.05	2.19	2.06	2.18	2.07	2.17	2.07	3
4	2.93	2.73	2.91	2.74	2.90	2.75	2.89	2.77	4
5	3.66	3.41	3.64	3.43	3.63	3.44	3.61	3.46	5
6	4.39	4.09	4.37	4.11	4.35	4.13	4.33	4.15	6
7	5.12	4.77	5.10	4.80	5.08	4.82	5.06	4.84	7
8	5.85	5.46	5.83	5.48	5.80	5.51	5.78	5.53	8
9	6.58	6.14	6.56	6.17	6.53	6.20	6.50	6.22	9
10	7.31	6.82	7.28	6.85	7.25	6.88	7.22	6.92	10
11	8.04	7.50	8.01	7.54	7.98	7.57	7.95	7.61	11
12	8.78	8.18	8.74	8.22	8.70	8.26	8.67	8.30	12
13	9.51	8.87	9.47	8.91	9.43	8.95	9.39	8.99	13
14	10.24	9.55	10.20	9.59	10.16	9.64	10.11	9.68	14
15	10.97	10.23	10.93	10.28	10.88	10.33	10.84	10.37	15
16	11.70	10.91	11.65	10.96	11.61	11.01	11.56	11.06	16
17	12.43	11.59	12.38	11.65	12.33	11.70	12.28	11.76	17
18	13.16	12.28	13.11	12.33	13.06	12.39	13.00	12.45	18
19	13.90	12.96	13.84	13.02	13.78	13.08	13.72	13.14	19
20	14.63	13.64	14.57	13.70	14.51	13.77	14.45	13.83	20
21	15.36	14.32	15.30	14.39	15.23	14.46	15.17	14.52	21
22	16.09	15.00	16.02	15.07	15.96	15.14	15.89	15.21	22
23	16.82	15.69	16.75	15.76	16.68	15.83	16.61	15.90	23
24	17.55	16.37	17.48	16.44	17.41	16.52	17.34	16.60	24
25	18.28	17.05	18.21	17.13	18.13	17.21	18.06	17.29	25
26	19.02	17.73	18.94	17.81	18.86	17.90	18.78	17.98	26
27	19.75	18.41	19.67	18.50	19.59	18.59	19.50	18.67	27
28	20.48	19.10	20.39	19.19	20.31	19.27	20.23	19.36	28
29	21.21	19.78	21.12	19.87	21.04	19.96	20.95	20.05	29
30	21.94	20.46	21.85	20.56	21.76	20.65	21.67	20.75	30
31	22.67	21.14	22.58	21.24	22.49	21.34	22.39	21.44	31
32	23.40	21.82	23.31	21.93	23.21	22.03	23.12	22.13	32
33	24.13	22.51	24.04	22.61	23.94	22.72	23.84	22.82	33
34	24.87	23.19	24.76	23.30	24.66	23.40	24.56	23.51	34
35	25.60	23.87	25.49	23.98	25.39	24.09	25.28	24.20	35
36	26.33	24.55	26.22	24.67	26.11	24.78	26.01	24.89	36
37	27.06	25.23	26.95	25.35	26.84	25.47	26.73	25.59	37
38	27.79	25.92	27.68	26.04	27.56	26.16	27.45	26.28	38
39	28.52	26.60	28.41	26.72	28.29	26.85	28.17	26.97	39
40	29.25	27.28	29.13	27.41	29.01	27.53	28.89	27.66	40
41	29.99	27.96	29.86	28.09	29.74	28.22	29.62	28.35	41
42	30.72	28.64	30.59	28.78	30.47	28.91	30.34	29.04	42
43	31.45	29.33	31.32	29.46	31.19	29.60	31.06	29.74	43
44	32.18	30.01	32.05	30.15	31.92	30.29	31.78	30.43	44
45	32.91	30.69	32.78	30.83	32.64	30.98	32.51	31.12	45
46	33.64	31.37	33.51	31.52	33.37	31.66	33.23	31.81	46
47	34.37	32.05	34.23	32.20	34.09	32.35	33.95	32.50	47
48	35.10	32.74	34.96	32.89	34.82	33.04	34.67	33.19	48
49	35.84	33.42	35.69	33.57	35.54	33.73	35.40	33.88	49
50	36.57	34.10	36.42	34.26	36.27	34.42	36.12	34.58	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	47 Deg.		46¾ Deg.		46½ Deg.		46¼ Deg.		

Distance.	43 Deg.		43¼ Deg.		43½ Deg.		43¾ Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	37.30	34.78	37.15	34.94	36.99	35.11	36.84	35.27	51
52	38.03	35.46	37.88	35.63	37.72	35.79	37.56	35.96	52
53	38.76	36.15	38.60	36.31	38.44	36.48	38.29	36.65	53
54	39.49	36.83	39.33	37.00	39.17	37.17	39.01	37.34	54
55	40.22	37.51	40.06	37.69	39.90	37.86	39.73	38.03	55
56	40.96	38.19	40.79	38.37	40.62	38.55	40.45	38.72	56
57	41.69	38.87	41.52	39.06	41.35	39.24	41.17	39.42	57
58	42.42	39.56	42.25	39.74	42.07	39.92	41.90	40.11	58
59	43.15	40.24	42.97	40.43	42.80	40.61	42.62	40.80	59
60	43.88	40.92	43.70	41.11	43.52	41.30	43.34	41.49	60
61	44.61	41.60	44.43	41.80	44.25	41.99	44.06	42.18	61
62	45.34	42.28	45.16	42.48	44.97	42.68	44.79	42.87	62
63	46.08	42.97	45.89	43.17	45.70	43.37	45.51	43.57	63
64	46.81	43.65	46.62	43.85	46.42	44.05	46.23	44.26	64
65	47.54	44.33	47.34	44.54	47.15	44.74	46.95	44.95	65
66	48.27	45.01	48.07	45.22	47.87	45.43	47.68	45.64	66
67	49.00	45.69	48.80	45.91	48.60	46.12	48.40	46.33	67
68	49.73	46.38	49.53	46.59	49.33	46.81	49.12	47.02	68
69	50.46	47.06	50.26	47.28	50.05	47.50	49.84	47.71	69
70	51.19	47.74	50.99	47.96	50.78	48.18	50.57	48.41	70
71	51.93	48.42	51.71	48.65	51.50	48.87	51.29	49.10	71
72	52.66	49.10	52.44	49.33	52.23	49.56	52.01	49.79	72
73	53.39	49.79	53.17	50.02	52.95	50.25	52.73	50.48	73
74	54.12	50.47	53.90	50.70	53.68	50.94	53.45	51.17	74
75	54.85	51.15	54.63	51.39	54.40	51.63	54.18	51.86	75
76	55.58	51.83	55.36	52.07	55.13	52.31	54.90	52.55	76
77	56.31	52.51	56.08	52.76	55.85	53.00	55.62	53.25	77
78	57.05	53.20	56.81	53.44	56.58	53.69	56.34	53.94	78
79	57.78	53.88	57.54	54.13	57.30	54.38	57.07	54.63	79
80	58.51	54.56	58.27	54.81	58.03	55.07	57.79	55.32	80
81	59.24	55.24	59.00	55.50	58.76	55.76	58.51	56.01	81
82	59.97	55.92	59.73	56.18	59.48	56.45	59.23	56.70	82
83	60.70	56.61	60.45	56.87	60.21	57.13	59.96	57.40	83
84	61.43	57.29	61.18	57.56	60.93	57.82	60.68	58.09	84
85	62.17	57.97	61.91	58.24	61.66	58.51	61.40	58.78	85
86	62.90	58.65	62.64	58.93	62.38	59.20	62.12	59.47	86
87	63.63	59.33	63.37	59.61	63.11	59.89	62.85	60.16	87
88	64.36	60.02	64.10	60.30	63.83	60.58	63.57	60.85	88
89	65.09	60.70	64.82	60.98	64.56	61.26	64.29	61.54	89
90	65.82	61.38	65.55	61.67	65.28	61.95	65.01	62.24	90
91	66.55	62.06	66.28	62.35	66.01	62.64	65.74	62.93	91
92	67.28	62.74	67.01	63.04	66.73	63.33	66.46	63.62	92
93	68.02	63.43	67.74	63.72	67.46	64.02	67.18	64.31	93
94	68.75	64.11	68.47	64.41	68.19	64.71	67.90	65.00	94
95	69.48	64.79	69.20	65.09	68.91	65.39	68.62	65.69	95
96	70.21	65.47	69.92	65.78	69.64	66.08	69.35	66.39	96
97	70.94	66.15	70.65	66.46	70.36	66.77	70.07	67.08	97
98	71.67	66.84	71.37	67.15	71.09	67.46	70.79	67.77	98
99	72.40	67.52	72.11	67.83	71.81	68.15	71.51	68.46	99
100	73.14	68.20	72.84	68.52	72.54	68.84	72.24	69.15	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	47 Deg.		46¾ Deg.		46½ Deg.		46¼ Deg.		

Distance.	44 Deg.		44¼ Deg.		44½ Deg.		44¾ Deg.		45 Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.72	0.69	0.72	0.70	0.71	0.70	0.71	0.71	0.71	0.71	1
2	1.44	1.39	1.43	1.40	1.43	1.40	1.42	1.41	1.41	1.41	2
3	2.16	2.08	2.15	2.09	2.14	2.10	2.13	2.11	2.12	2.12	3
4	2.88	2.78	2.87	2.79	2.85	2.80	2.84	2.82	2.83	2.83	4
5	3.60	3.47	3.58	3.49	3.57	3.50	3.55	3.52	3.54	3.54	5
6	4.32	4.17	4.30	4.19	4.28	4.21	4.26	4.22	4.24	4.24	6
7	5.04	4.86	5.01	4.88	4.99	4.91	4.97	4.93	4.95	4.95	7
8	5.75	5.56	5.73	5.58	5.71	5.61	5.68	5.63	5.66	5.66	8
9	6.47	6.25	6.45	6.28	6.42	6.31	6.39	6.34	6.36	6.36	9
10	7.19	6.95	7.16	6.98	7.13	7.01	7.10	7.04	7.07	7.07	10
11	7.91	7.64	7.88	7.68	7.85	7.71	7.81	7.74	7.78	7.78	11
12	8.63	8.34	8.60	8.37	8.56	8.41	8.52	8.45	8.49	8.49	12
13	9.35	9.03	9.31	9.07	9.27	9.11	9.23	9.15	9.19	9.19	13
14	10.07	9.73	10.03	9.77	9.99	9.81	9.94	9.86	9.90	9.90	14
15	10.79	10.42	10.74	10.47	10.70	10.51	10.65	10.56	10.61	10.61	15
16	11.51	11.11	11.46	11.16	11.41	11.21	11.36	11.26	11.31	11.31	16
17	12.23	11.81	12.18	11.86	12.13	11.92	12.07	11.97	12.02	12.02	17
18	12.95	12.50	12.89	12.56	12.84	12.62	12.78	12.67	12.73	12.73	18
19	13.67	13.20	13.61	13.26	13.55	13.32	13.49	13.38	13.43	13.43	19
20	14.39	13.89	14.33	13.96	14.26	14.02	14.20	14.08	14.14	14.14	20
21	15.11	14.59	15.04	14.65	14.98	14.72	14.91	14.78	14.85	14.85	21
22	15.83	15.28	15.76	15.35	15.69	15.42	15.62	15.49	15.56	15.56	22
23	16.54	15.98	16.47	16.05	16.40	16.12	16.33	16.19	16.26	16.26	23
24	17.26	16.67	17.19	16.75	17.12	16.82	17.04	16.90	16.97	16.97	24
25	17.98	17.37	17.91	17.44	17.83	17.52	17.75	17.60	17.68	17.68	25
26	18.70	18.06	18.62	18.14	18.54	18.22	18.46	18.30	18.38	18.38	26
27	19.42	18.76	19.34	18.84	19.26	18.92	19.17	19.01	19.09	19.09	27
28	20.14	19.45	20.06	19.54	19.97	19.63	19.89	19.71	19.80	19.80	28
29	20.86	20.15	20.77	20.24	20.68	20.33	20.60	20.42	20.51	20.51	29
30	21.58	20.84	21.49	20.93	21.40	21.03	21.31	21.12	21.21	21.21	30
31	22.30	21.53	22.21	21.63	22.11	21.73	22.02	21.82	21.92	21.92	31
32	23.02	22.23	22.92	22.33	22.82	22.43	22.73	22.53	22.63	22.63	32
33	23.74	22.92	23.64	23.03	23.54	23.13	23.44	23.23	23.33	23.33	33
34	24.46	23.62	24.35	23.72	24.25	23.83	24.15	23.94	24.04	24.04	34
35	25.18	24.31	25.07	24.42	24.96	24.53	24.86	24.64	24.75	24.75	35
36	25.90	25.01	25.79	25.12	25.68	25.23	25.57	25.34	25.46	25.46	36
37	26.62	25.70	26.50	25.82	26.39	25.93	26.28	26.05	26.16	26.16	37
38	27.33	26.40	27.22	26.52	27.10	26.63	26.99	26.75	26.87	26.87	38
39	28.05	27.09	27.94	27.21	27.82	27.34	27.70	27.46	27.58	27.58	39
40	28.77	27.79	28.65	27.91	28.53	28.04	28.41	28.16	28.28	28.28	40
41	29.49	28.48	29.37	28.61	29.24	28.74	29.12	28.86	28.99	28.99	41
42	30.21	29.18	30.08	29.31	29.96	29.44	29.83	29.57	29.70	29.70	42
43	30.93	29.87	30.80	30.00	30.67	30.14	30.54	30.27	30.41	30.41	43
44	31.65	30.56	31.52	30.70	31.38	30.84	31.25	30.98	31.11	31.11	44
45	32.37	31.26	32.23	31.40	32.10	31.54	31.96	31.68	31.82	31.82	45
46	33.09	31.95	32.95	32.10	32.81	32.24	32.67	32.38	32.53	32.53	46
47	33.81	32.65	33.67	32.80	33.52	32.94	33.38	33.09	33.23	33.23	47
48	34.53	33.34	34.38	33.49	34.24	33.64	34.09	33.79	33.94	33.94	48
49	35.25	34.04	35.10	34.19	34.95	34.34	34.80	34.50	34.65	34.65	49
50	35.97	34.73	35.82	34.89	35.66	35.05	35.51	35.20	35.36	35.36	50
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	46 Deg.		45¾ Deg.		45½ Deg.		45¼ Deg.		45 Deg.		

Distance.	44 Deg.		44¼ Deg.		44½ Deg.		44¾ Deg.		45 Deg.		Distance.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
51	36.69	35.43	36.53	35.59	36.38	35.75	36.22	35.90	36.06	36.06	51
52	37.41	36.12	37.25	36.29	37.09	36.45	36.93	36.61	36.77	36.77	52
53	38.12	36.82	37.96	36.98	37.80	37.15	37.64	37.31	37.48	37.48	53
54	38.84	37.51	38.68	37.68	38.52	37.85	38.35	38.02	38.18	38.18	54
55	39.56	38.21	39.40	38.38	39.23	38.55	39.06	38.72	38.89	38.89	55
56	40.28	38.90	40.11	39.08	39.94	39.25	39.77	39.42	39.60	39.60	56
57	41.00	39.60	40.83	39.77	40.66	39.95	40.48	40.13	40.31	40.31	57
58	41.72	40.29	41.55	40.47	41.37	40.65	41.19	40.83	41.01	41.01	58
59	42.44	40.98	42.26	41.17	42.08	41.35	41.90	41.54	41.72	41.72	59
60	43.16	41.68	42.98	41.87	42.79	42.05	42.61	42.24	42.43	42.43	60
61	43.88	42.37	43.69	42.57	43.51	42.76	43.32	42.94	43.13	43.13	61
62	44.60	43.07	44.41	43.26	44.22	43.46	44.03	43.65	43.84	43.84	62
63	45.32	43.76	45.13	43.96	44.93	44.16	44.74	44.35	44.55	44.55	63
64	46.04	44.46	45.84	44.66	45.65	44.86	45.45	45.06	45.25	45.25	64
65	46.76	45.15	46.56	45.36	46.36	45.56	46.16	45.76	45.96	45.96	65
66	47.48	45.85	47.28	46.05	47.07	46.26	46.87	46.46	46.67	46.67	66
67	48.20	46.54	47.99	46.75	47.79	46.96	47.58	47.17	47.38	47.38	67
68	48.92	47.24	48.71	47.45	48.50	47.66	48.29	47.87	48.08	48.08	68
69	49.63	47.93	49.42	48.15	49.21	48.36	49.00	48.58	48.79	48.79	69
70	50.35	48.63	50.14	48.85	49.93	49.06	49.71	49.28	49.50	49.50	70
71	51.07	49.32	50.86	49.54	50.64	49.76	50.42	49.98	50.20	50.20	71
72	51.79	50.02	51.57	50.24	51.35	50.47	51.13	50.69	50.91	50.91	72
73	52.51	50.71	52.29	50.94	52.07	51.17	51.84	51.39	51.62	51.62	73
74	53.23	51.40	53.01	51.64	52.78	51.87	52.55	52.10	52.33	52.33	74
75	53.95	52.10	53.72	52.33	53.49	52.57	53.26	52.80	53.03	53.03	75
76	54.67	52.79	54.44	53.03	54.21	53.27	53.97	53.51	53.74	53.74	76
77	55.39	53.49	55.16	53.73	54.92	53.97	54.68	54.21	54.45	54.45	77
78	56.11	54.18	55.87	54.43	55.63	54.67	55.39	54.91	55.15	55.15	78
79	56.83	54.88	56.59	55.13	56.35	55.37	56.10	55.62	55.86	55.86	79
80	57.55	55.57	57.30	55.82	57.06	56.07	56.81	56.32	56.57	56.57	80
81	58.27	56.27	58.02	56.52	57.77	56.77	57.52	57.03	57.28	57.28	81
82	58.99	56.96	58.74	57.22	58.49	57.47	58.24	57.73	57.98	57.98	82
83	59.71	57.66	59.45	57.92	59.20	58.18	58.95	58.43	58.69	58.69	83
84	60.42	58.35	60.17	58.61	59.91	58.88	59.66	59.14	59.40	59.40	84
85	61.14	59.05	60.89	59.31	60.63	59.58	60.37	59.84	60.10	60.10	85
86	61.86	59.74	61.60	60.01	61.34	60.28	61.08	60.55	60.81	60.81	86
87	62.58	60.44	62.32	60.71	62.05	60.98	61.79	61.25	61.52	61.52	87
88	63.30	61.13	63.03	61.41	62.77	61.68	62.50	61.95	62.23	62.23	88
89	64.02	61.82	63.75	62.10	63.48	62.38	63.21	62.66	62.93	62.93	89
90	64.74	62.52	64.47	62.80	64.19	63.08	63.92	63.36	63.64	63.64	90
91	65.46	63.21	65.18	63.50	64.91	63.78	64.63	64.07	64.35	64.35	91
92	66.18	63.91	65.90	64.20	65.62	64.48	65.34	64.77	65.05	65.05	92
93	66.90	64.60	66.62	64.89	66.33	65.18	66.05	65.47	65.76	65.76	93
94	67.62	65.30	67.33	65.59	67.05	65.89	66.76	66.18	66.47	66.47	94
95	68.34	65.99	68.05	66.29	67.76	66.59	67.47	66.88	67.18	67.18	95
96	69.06	66.69	68.76	66.90	68.47	67.29	68.18	67.59	67.88	67.88	96
97	69.78	67.38	69.48	67.69	69.19	67.99	68.89	68.29	68.59	68.59	97
98	70.50	68.08	70.20	68.38	69.90	68.69	69.60	68.99	69.30	69.30	98
99	71.21	68.77	70.91	69.08	70.61	69.39	70.31	69.70	70.00	70.00	99
100	71.93	69.47	71.63	69.78	71.33	70.09	71.02	70.40	70.71	70.71	100
Distance.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance.
	46 Deg.		45¾ Deg.		45½ Deg.		45¼ Deg.		45 Deg.		

A TABLE
OF
LOGARITHMS,
FROM 1 TO 10,000.

Note. The index of the logarithm of every integer number consisting of only one figure is 0, of two figures 1, of three figures 2, of four figures 3; being always a unit less than the number of figures contained in the integer number. In this table, as is generally the case, the index to the logarithm of every number above 100 is omitted; yet in the operation must be prefixed according to this remark; so the logarithm of 700 is 2,84510, and of 7000 is 3,84510, and so of the rest.

No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0.00000	21	1.32222	41	1.61278	61	1.78533	81	1.90849
2	0.30103	22	1.34242	42	1.62325	62	1.79239	82	1.91381
3	0.47712	23	1.36173	43	1.63347	63	1.79934	83	1.91908
4	0.60206	24	1.38021	44	1.64345	64	1.80618	84	1.92428
5	0.69897	25	1.39794	45	1.65321	65	1.81291	85	1.92942
6	0.77815	26	1.41497	46	1.66276	66	1.81954	86	1.93450
7	0.84510	27	1.43136	47	1.67210	67	1.82607	87	1.93952
8	0.90309	28	1.44716	48	1.68124	68	1.83251	88	1.94448
9	0.95424	29	1.46240	49	1.69020	69	1.83885	89	1.94939
10	1.00000	30	1.47712	50	1.69897	70	1.84510	90	1.95424
11	1.04139	31	1.49136	51	1.70757	71	1.85126	91	1.95904
12	1.07918	32	1.50515	52	1.71600	72	1.85733	92	1 96379
13	1.11394	33	1.51851	53	1.72428	73	1.86332	93	1.96848
14	1.14613	34	1.53148	54	1.73239	74	1.86923	94	1.97313
15	1.17609	35	1.54407	55	1.74036	75	1.87506	95	1.97772
16	1.20412	36	1.55630	56	1.74819	76	1.88081	96	1.98227
17	1.23045	37	1.56820	57	1.75587	77	1.88649	97	1.98677
18	1.25527	38	1.57978	58	1.76343	78	1.89209	98	1.99123
19	1.27875	39	1.59106	59	1.77085	79	1.89763	99	1.99564
20	1.30103	40	1.60206	60	1.77815	80	1.90309	100	2.00000

No.	0	1	2	3	4	5	6	7	8	9
100	00000	00043	00087	00130	00173	00217	00260	00303	00346	00389
101	00432	00475	00518	00561	00604	00647	00689	00732	00775	00817
102	00860	00903	00945	00988	01030	01072	01115	01157	01199	01242
103	01284	01326	01368	01410	01452	01494	01536	01578	01620	01662
104	01703	01745	01787	01828	01870	01912	01953	01995	02036	02078
105	02119	02160	02202	02243	02284	02325	02366	02407	02449	02490
106	02531	02572	02612	02653	02694	02735	02776	02816	02857	02898
107	02938	02979	03019	03060	03100	03141	03181	03222	03262	03302
108	03342	03383	03423	03463	03503	03543	03583	03623	03663	03703
109	03743	03782	03822	03862	03902	03941	03981	04021	04060	04100
110	04139	04179	04218	04258	04297	04336	04376	04415	04454	04493
111	04532	04571	04610	04650	04689	04727	04766	04805	04844	04883
112	04922	04961	04999	05038	05077	05115	05154	05192	05231	05269
113	05308	05346	05385	05423	05461	05500	05538	05576	05614	05652
114	05690	05729	05767	05805	05843	05881	05918	05956	05994	06032
115	06070	06108	06145	06183	06221	06258	06296	06333	06371	06408
116	06446	06483	06521	06558	06595	06633	06670	06707	06744	06781
117	06819	06856	06893	06930	06967	07004	07041	07078	07115	07151
118	07188	07225	07262	07298	07335	07372	07408	07445	07482	07518
119	07555	07591	07628	07664	07700	07737	07773	07809	07846	07882
120	07918	07954	07990	08027	08063	08099	08135	08171	08207	08243
121	08279	08314	08350	08386	08422	08458	08493	08529	08565	08600
122	08636	08672	08707	08743	08778	08814	08849	08884	08920	08955
123	08991	09026	09061	09096	09132	09167	09202	09237	09272	09307
124	09342	09377	09412	09447	09482	09517	09552	09587	09621	09656
125	09691	09726	09760	09795	09830	09864	09899	09934	09968	10003
126	10037	10072	10106	10140	10175	10209	10243	10278	10312	10346
127	10380	10415	10449	10483	10517	10551	10585	10619	10653	10687
128	10721	10755	10789	10823	10857	10890	10924	10958	10992	11025
129	11059	11093	11126	11160	11193	11227	11261	11294	11327	11361
130	11394	11428	11461	11494	11528	11561	11594	11628	11661	11694
131	11727	11760	11793	11826	11860	11893	11926	11959	11992	12024
132	12057	12090	12123	12156	12189	12222	12254	12287	12320	12352
133	12385	12418	12450	12483	12516	12548	12581	12613	12646	12678
134	12710	12743	12775	12808	12840	12872	12905	12937	12969	13001
135	13033	13066	13098	13130	13162	13194	13226	13258	13290	13322
136	13354	13386	13418	13450	13481	13513	13545	13577	13609	13640
137	13672	13704	13735	13767	13799	13830	13862	13893	13925	13956
138	13988	14019	14051	14082	14114	14145	14176	14208	14239	14270
139	14301	14333	14364	14395	14426	14457	14489	14520	14551	14582
140	14613	14644	14675	14706	14737	14768	14799	14829	14860	14891
141	14922	14953	14983	15014	15045	15076	15106	15137	15168	15198
142	15229	15259	15290	15320	15351	15381	15412	15442	15473	15503
143	15534	15564	15594	15625	15655	15685	15715	15746	15776	15806
144	15836	15866	15897	15927	15957	15987	16017	16047	16077	16107
145	16137	16167	16197	16227	16256	16286	16316	16346	16376	16406
146	16435	16465	16495	16524	16554	16584	16613	16643	16673	16702
147	16732	16761	16791	16820	16850	16879	16909	16938	16967	16997
148	17026	17056	17085	17114	17143	17173	17202	17231	17260	17289
149	17319	17348	17377	17406	17435	17464	17493	17522	17551	17580
150	17609	17638	17667	17696	17725	17754	17782	17811	17840	17869
151	17898	17926	17955	17984	18013	18041	18070	18099	18127	18156
152	18184	18213	18241	18270	18298	18327	18355	18384	18412	18441
153	18469	18498	18526	18554	18583	18611	18639	18667	18696	18724
154	18752	18780	18808	18837	18865	18893	18921	18949	18977	19005
155	19033	19061	19089	19117	19145	19173	19201	19229	19257	19285
156	19312	19340	19368	19396	19424	19451	19479	19507	19535	19562
157	19590	19618	19645	19673	19700	19728	19756	19783	19811	19838
158	19866	19893	19921	19948	19976	20003	20030	20058	20085	20112
159	20140	20167	20194	20222	20249	20276	20303	20330	20358	20385

No.	0	1	2	3	4	5	6	7	8	9
160	20412	20439	20466	20493	20520	20548	20575	20602	20629	20656
161	20683	20710	20737	20763	20790	20817	20844	20871	20898	20925
162	20952	20978	21005	21032	21059	21085	21112	21139	21165	21192
163	21219	21245	21272	21299	21325	21352	21378	21405	21431	21458
164	21484	21511	21537	21564	21590	21617	21643	21669	21696	21722
165	21748	21775	21801	21827	21854	21880	21906	21932	21958	21985
166	22011	22037	22063	22089	22115	22141	22167	22194	22220	22246
167	22272	22298	22324	22350	22376	22401	22427	22453	22479	22505
168	22531	22557	22583	22608	22634	22660	22686	22712	22737	22763
169	22789	22814	22840	22866	22891	22917	22943	22968	22994	23019
170	23045	23070	23096	23121	23147	23172	23198	23223	23249	23274
171	23300	23325	23350	23376	23401	23426	23452	23477	23502	23528
172	23553	23578	23603	23629	23654	23679	23704	23729	23754	23779
173	23805	23830	23855	23880	23905	23930	23955	23980	24005	24030
174	24055	24080	24105	24130	24155	24180	24204	24229	24254	24279
175	24304	24329	24353	24378	24403	24428	24452	24477	24502	24527
176	24551	24576	24601	24625	24650	24674	24699	24724	24748	24773
177	24797	24822	24846	24871	24895	24920	24944	24969	24993	25018
178	25042	25066	25091	25115	25139	25164	25188	25212	25237	25261
179	25285	25310	25334	25358	25382	25406	25431	25455	25479	25503
180	25527	25551	25575	25600	25624	25648	25672	25696	25720	25744
181	25768	25792	25816	25840	25864	25888	25912	25935	25959	25983
182	26007	26031	26055	26079	26102	26126	26150	26174	26198	26221
183	26245	26269	26293	26316	26340	26364	26387	26411	26435	26458
184	26482	26505	26529	26553	26576	26600	26623	26647	26670	26694
185	26717	26741	26764	26788	26811	26834	26858	26881	26905	26928
186	26951	26975	26998	27021	27045	27068	27091	27114	27138	27161
187	27184	27207	27231	27254	27277	27300	27323	27346	27370	27393
188	27416	27439	27462	27485	27508	27531	27554	27577	27600	27623
189	27646	27669	27692	27715	27738	27761	27784	27807	27830	27852
190	27875	27898	27921	27944	27967	27989	28012	28035	28058	28081
191	28103	28126	28149	28171	28194	28217	28240	28262	28285	28307
192	28330	28353	28375	28398	28421	28443	28466	28488	28511	28533
193	28556	28578	28601	28623	28646	28668	28691	28713	28735	28758
194	28780	28803	28825	28847	28870	28892	28914	28937	28959	28981
195	29003	29026	29048	29070	29092	29115	29137	29159	29181	29203
196	29226	29248	29270	29292	29314	29336	29358	29380	29403	29425
197	29447	29469	29491	29513	29535	29557	29579	29601	29623	29645
198	29667	29688	29710	29732	29754	29776	29798	29820	29842	29863
199	29885	29907	29929	29951	29973	29994	30016	30038	30060	30081
200	30103	30125	30146	30168	30190	30211	30233	30255	30276	30298
201	30320	30341	30363	30384	30406	30428	30449	30471	30492	30514
202	30535	30557	30578	30600	30621	30643	30664	30685	30707	30728
203	30750	30771	30792	30814	30835	30856	30878	30899	30920	30942
204	30963	30984	31006	31027	31048	31069	31091	31112	31133	31154
205	31175	31197	31218	31239	31260	31281	31302	31323	31345	31366
206	31387	31408	31429	31450	31471	31492	31513	31534	31555	31576
207	31597	31618	31639	31660	31681	31702	31723	31744	31765	31785
208	31806	31827	31848	31869	31890	31911	31931	31952	31973	31994
209	32015	32035	32056	32077	32098	32118	32139	32160	32181	32201
210	32222	32243	32263	32284	32305	32325	32346	32366	32387	32408
211	32428	32449	32469	32490	32510	32531	32552	32572	32593	32613
212	32634	32654	32675	32695	32715	32736	32756	32777	32797	32818
213	32838	32858	32879	32899	32919	32940	32960	32980	33001	33021
214	33041	33062	33082	33102	33122	33143	33163	33183	33203	33224
215	33244	33264	33284	33304	33325	33345	33365	33385	33405	33425
216	33445	33465	33486	33506	33526	33546	33566	33586	33606	33626
217	33646	33666	33686	33706	33726	33746	33766	33786	33806	33826
218	33846	33866	33885	33905	33925	33945	33965	33985	34005	34025
219	34044	34064	34084	34104	34124	34143	34163	34183	34203	34223

No.	0	1	2	3	4	5	6	7	8	9
220	34242	34262	34282	34301	34321	34341	34361	34380	34400	34420
221	34439	34459	34479	34498	34518	34537	34557	34577	34596	34616
222	34635	34655	34674	34694	34713	34733	34753	34772	34792	34811
223	34830	34850	34869	34889	34908	34928	34947	34967	34986	35005
224	35025	35044	35064	35083	35102	35122	35141	35160	35180	35199
225	35218	35238	35257	35276	35295	35315	35334	35353	35372	35392
226	35411	35430	35449	35468	35488	35507	35526	35545	35564	35583
227	35603	35622	35641	35660	35679	35698	35717	35736	35755	35774
228	35793	35813	35832	35851	35870	35889	35908	35927	35946	35965
229	35984	36003	36021	36040	36059	36078	36097	36116	36135	36154
230	36173	36192	36211	36229	36248	36267	36286	36305	36324	36342
231	36361	36380	36399	36418	36436	36455	36474	36493	36511	26530
232	36549	36568	36586	36605	36624	36642	36661	36680	36698	36717
233	36736	36754	36773	36791	36810	36829	36847	36866	36884	36903
234	36922	36940	36959	36977	36996	37014	37033	37051	37070	37088
235	37107	37125	37144	37162	37181	37199	37218	37236	37254	37273
236	37291	37310	37328	37346	37365	37383	37401	37420	37438	37457
237	37475	37493	37511	37530	37548	37566	37585	37603	37621	37639
238	37658	37676	37694	37712	37731	37749	37767	37785	37803	37822
239	37840	37858	37876	37894	37912	37931	37949	37967	37985	38003
240	38021	38039	38057	38075	38093	38112	38130	38148	38166	38184
241	38202	38220	38238	38256	38274	38292	38310	38328	38346	38364
242	38382	38399	38417	38435	38453	38471	38489	38507	38525	38543
243	38561	38578	38596	38614	38632	38650	38668	38686	38703	38721
244	38739	38757	38775	38792	38810	38828	38846	38863	38881	38899
245	38917	38934	38952	38970	38987	39005	39023	39041	39058	39076
246	39094	39111	39129	39146	39164	39182	39199	39217	39235	39252
247	39270	39287	39305	39322	39340	39358	39375	39393	39410	39428
248	39445	39463	39480	39498	39515	39533	39550	39568	39585	39602
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937	97174	97179	97183	97188	97192	97197	97202	97206	97211	97216
938	97220	97225	97230	97234	97239	97243	97248	97253	97257	97262
939	97267	97271	97276	97280	97285	97290	97294	97299	97304	97308

No.	0	1	2	3	4	5	6	7	8	9
940	97313	97317	97322	97327	97331	97336	97340	97345	97350	97354
941	97359	97364	97368	97373	97377	97382	97387	97391	97396	97400
942	97405	97410	97414	97419	97424	97428	97433	97437	97442	97447
943	97451	97456	97460	97465	97470	97474	97479	97483	97488	97493
944	97497	97502	97506	97511	97516	97520	97525	97529	97534	97539
945	97543	97548	97552	97557	97562	97566	97571	97575	97580	97585
946	97589	97594	97598	97603	97607	97612	97617	97621	97626	97630
947	97635	97640	97644	97649	97653	97658	97663	97667	97672	97676
948	97681	97685	97690	97695	97699	97704	97708	97713	97717	97722
949	97727	97731	97736	97740	97745	97749	97754	97759	97763	97768
950	97772	97777	97782	97786	97791	97795	97800	97804	97809	97813
951	97818	97823	97827	97832	97836	97841	97845	97850	97855	97859
952	97864	97868	97873	97877	97882	97886	97891	97896	97900	97905
953	97909	97914	97918	97923	97928	97932	97937	97941	97946	97950
954	97955	97959	97964	97968	97973	97978	97982	97987	97991	97996
955	98000	98005	98009	98014	98019	98023	98028	98032	98037	98041
956	98046	98050	98055	98059	98064	98068	98073	98078	98082	98087
957	98091	98096	98100	98105	98109	98114	98118	98123	98127	98132
958	98137	98141	98146	98150	98155	98159	98164	98168	98173	98177
959	98182	98186	98191	98195	98200	98204	98209	98214	98218	98223
960	98227	98232	98236	98241	98245	98250	98254	98259	98263	98268
961	98272	98277	98281	98286	98290	98295	98299	98304	98308	98313
962	98318	98322	98327	98331	98336	98340	98345	98349	98354	98358
963	98363	98367	98372	98376	98381	98385	98390	98394	98399	98403
964	98408	98412	98417	98421	98426	98430	98435	98439	98444	98448
965	98453	98457	98462	98466	98471	98475	98480	98484	98489	98493
966	98498	98502	98507	98511	98516	98520	98525	98529	98534	98538
967	98543	98547	98552	98556	98561	98565	98570	98574	98579	98583
968	98588	98592	98597	98601	98605	98610	98614	98619	98623	98628
969	98632	98637	98641	98646	98650	98655	98659	98664	98668	98673
970	98677	98682	98686	98691	98695	98700	98704	98709	98713	98717
971	98722	98726	98731	98735	98740	98744	98749	98753	98758	98762
972	98767	98771	98776	98780	98784	98789	98793	98798	98802	98807
973	98811	98816	98820	98825	98829	98834	98838	98843	98847	98851
974	98856	98860	98865	98869	98874	98878	98883	98887	98892	98896
975	98900	98905	98909	98914	98918	98923	98927	98932	98936	98941
976	98945	98949	98954	98958	98963	98967	98972	98976	98981	98985
977	98989	98994	98998	99003	99007	99012	99016	99021	99025	99029
978	99034	99038	99043	99047	99052	99056	99061	99065	99069	99074
979	99078	99083	99087	99092	99096	99100	99105	99109	99114	99118
980	99123	99127	99131	99136	99140	99145	99149	99154	99158	99162
981	99167	99171	99176	99180	99185	99189	99193	99198	99202	99207
982	99211	99216	99220	99224	99229	99233	99238	99242	99247	99251
983	99255	99260	99264	99269	99273	99277	99282	99286	99291	99295
984	99300	99304	99308	99313	99317	99322	99326	99330	99335	99339
985	99344	99348	99352	99357	99361	99366	99370	99374	99379	99383
986	99388	99392	99396	99401	99405	99410	99414	99419	99423	99427
987	99432	99436	99441	99445	99449	99454	99458	99463	99467	99471
988	99476	99480	99484	99489	99493	99498	99502	99506	99511	99515
989	99520	99524	99528	99533	99537	99542	99546	99550	99555	99559
990	99564	99568	99572	99577	99581	99585	99590	99594	99599	99603
991	99607	99612	99616	99621	99625	99629	99634	99638	99642	99647
992	99651	99656	99660	99664	99669	99673	99677	99682	99686	99691
993	99695	99699	99704	99708	99712	99717	99721	99726	99730	99734
994	99739	99743	99747	99752	99756	99760	99765	99769	99774	99778
995	99782	99787	99791	99795	99800	99804	99808	99813	99817	99822
996	99826	99830	99835	99839	99843	99848	99852	99856	99861	99865
997	99870	99874	99878	99883	99887	99891	99896	99900	99904	99909
998	99913	99917	99922	99926	99930	99935	99939	99944	99948	99952
999	99957	99961	99965	99970	99974	99978	99983	99987	99991	99996

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	Inf. Neg.	10.00000	Inf. Neg.	Infinite.	10.00000	Infinite.	60
1	6.46373	10.00000	6.46373	13.53627	10.00000	13.53627	59
2	76476	00000	76476	23524	00000	23524	58
3	94085	00000	94085	05915	00000	05915	57
4	7.06579	00000	7.06579	12.93421	00000	12.93421	56
5	16270	00000	16270	83730	00000	83730	55
6	24188	00000	24188	75812	00000	75812	54
7	30882	00000	30882	69118	00000	69118	53
8	36682	00000	36682	63318	00000	63318	52
9	41797	00000	41797	58203	00000	58203	51
10	46373	00000	46373	53627	00000	53627	50
11	7.50512	10.00000	7.50512	12.49488	10.00000	12.49488	49
12	54291	00000	54291	45709	00000	45709	48
13	57767	00000	57767	42233	00000	42233	47
14	60985	00000	60986	39014	00000	39015	46
15	63982	00000	63982	36018	00000	36018	45
16	66784	00000	66785	33215	00000	33216	44
17	69417	9.99999	69418	30582	00001	30583	43
18	71900	99999	71900	28100	00001	28100	42
19	74248	99999	74248	25752	00001	25752	41
20	76475	99999	76476	23524	00001	23525	40
21	7.78594	9.99999	7.78595	12.21405	10.00001	12.21406	39
22	80615	99999	80615	19385	00001	19385	38
23	82545	99999	82546	17454	00001	17455	37
24	84393	99999	84394	15606	00001	15607	36
25	86166	99999	86167	13833	00001	13834	35
26	87870	99999	87871	12129	00001	12130	34
27	89509	99999	89510	10490	00001	10491	33
28	91088	99999	91089	08911	00001	08912	32
29	92612	99998	92613	07387	00002	07388	31
30	94084	99998	94086	05914	00002	05916	30
31	7.95508	9.99998	7.95510	12.04490	10.00002	12.04492	29
32	96887	99998	96889	03111	00002	03113	28
33	98223	99998	98225	01775	00002	01777	27
34	99520	99998	99522	00478	00002	00480	26
35	8.00779	99998	8.00781	11.99219	00002	11.99221	25
36	02002	99998	02004	97996	00002	97998	24
37	03192	99997	03194	96806	00003	96808	23
38	04350	99997	04353	95647	00003	95650	22
39	05478	99997	05481	94519	00003	94522	21
40	06578	99997	06581	93419	00003	93422	20
41	8.07650	9.99997	8.07653	11.92347	10.00003	11.92350	19
42	08696	99997	08700	91300	00003	91304	18
43	09718	99997	09722	90278	00003	90282	17
44	10717	99996	10720	89280	00004	89283	16
45	11693	99996	11696	88304	00004	88307	15
46	12647	99996	12651	87349	00004	87353	14
47	13581	99996	13585	86415	00004	86419	13
48	14495	99996	14500	85500	00004	85505	12
49	15391	99996	15395	8460[illegible]	00004	84609	11
50	16268	99995	16273	83727	00005	83732	10
51	8.17128	9.99995	8.17133	11.82867	10.00005	11.82872	9
52	17971	99995	17976	82024	00005	82029	8
53	18798	99995	18804	81196	00005	81202	7
54	19610	99995	19616	80384	00005	80390	6
55	20407	99994	20413	79587	00006	79593	5
56	21189	99994	21195	78805	00006	78811	4
57	21958	99994	21964	78036	00006	78042	3
58	22713	99994	22720	77280	00006	77287	2
59	23456	99994	23462	76538	00006	76544	1
60	24186	99993	24192	75808	00007	75814	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

89 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	8.24186	9.99993	8.24192	11.75808	10.00007	11.75814	60
1	24903	99993	24910	75090	00007	75097	59
2	25609	99993	25616	74384	00007	74391	58
3	26304	99993	26312	73688	00007	73696	57
4	26988	99992	26996	73004	00008	73012	56
5	27661	99992	27669	72331	00008	72339	55
6	28324	99992	28332	71668	00008	71676	54
7	28977	99992	28986	71014	00008	71023	53
8	29621	99992	29629	70371	00008	70379	52
9	30255	99991	30263	69737	00009	69745	51
10	8.30879	9.99991	8.30888	11.69112	10.00009	11.69121	50
11	31495	99991	31505	68495	00009	68505	49
12	32103	99990	32112	67888	00010	67897	48
13	32702	99990	32711	67289	00010	67298	47
14	33292	99990	33302	66698	00010	66708	46
15	33875	99990	33886	66114	00010	66125	45
16	34450	99989	34461	65539	00011	65550	44
17	35018	99989	35029	64971	00011	64982	43
18	35578	99989	35590	64410	00011	64422	42
19	36131	99989	36143	63857	00011	63869	41
20	8.36678	9.99988	8.36689	11.63311	10.00012	11.63322	40
21	37217	99988	37229	62771	00012	62783	39
22	37750	99988	37762	62238	00012	62250	38
23	38276	99987	38289	61711	00013	61724	37
24	38796	99987	38809	61191	00013	61204	36
25	39310	99987	39323	60677	00013	60690	35
26	39818	99986	39832	60168	00014	60182	34
27	40320	99986	40334	59666	00014	59680	33
28	40816	99986	40830	59170	00014	59184	32
29	41307	99985	41321	58679	00015	58693	31
30	8.41792	9.99985	8.41807	11.58193	10.00015	11.58208	30
31	42272	99985	42287	57713	00015	57728	29
32	42746	99984	42762	57238	00016	57254	28
33	43216	99984	43232	56768	00016	56784	27
34	43680	99984	43696	56304	00016	56320	26
35	44139	99983	44156	55844	00017	55861	25
36	44594	99983	44611	55389	00017	55406	24
37	45044	99983	45061	54939	00017	54956	23
38	45489	99982	45507	54493	00018	54511	22
39	45930	99982	45948	54052	00018	54070	21
40	8.46366	9.99982	8.46385	11.53615	10.00018	11.53634	20
41	46799	90981	46817	53183	00019	53201	19
42	47226	99981	47245	52755	00019	52774	18
43	47650	99981	47669	52331	00019	52350	17
44	48069	99980	48089	51911	00020	51931	16
45	48485	99980	48505	51495	00020	51515	15
46	48896	99979	48917	51083	00021	51104	14
47	49304	99979	49325	50675	00021	50696	13
48	49708	99979	49729	50271	00021	50292	12
49	50108	99978	50130	49870	00022	49892	11
50	8.50504	9.99978	8.50527	11.49473	10.00022	11.49496	10
51	50897	99977	50920	49080	00023	49103	9
52	51287	99977	51310	48690	00023	48713	8
53	51673	99977	51696	48304	00023	48327	7
54	52055	99976	52079	47921	00024	47945	6
55	52434	99976	52459	47541	00024	47566	5
56	52810	99975	52835	47165	00025	47190	4
57	53183	99975	53208	46792	00025	46817	3
58	53552	99974	53578	46422	00026	46448	2
59	53919	99974	53945	46055	00026	46081	1
60	54282	99974	54308	45692	00026	45718	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	8.54282	9.99974	8.54308	11.45692	10.00026	11.45718	60
1	54642	99973	54669	45331	00027	45358	59
2	54999	99973	55027	44973	00027	45001	58
3	55354	99972	55382	44618	00028	44646	57
4	55705	99972	55734	44266	00028	44295	56
5	56054	99971	56083	43917	00029	43946	55
6	56400	99971	56429	43571	00029	43600	54
7	56743	99970	56773	43227	00030	43257	53
8	57084	99970	57114	42886	00030	42916	52
9	57421	99969	57452	42548	00031	42579	51
10	8.57757	9.99969	8.57788	11.42212	10.00031	11.42243	50
11	58089	99968	58121	41879	00032	41911	49
12	58419	99968	58451	41549	00032	41581	48
13	58747	99967	58779	41221	00033	41253	47
14	59072	99967	59105	40895	00033	40928	46
15	59395	99967	59428	40572	00033	40605	45
16	59715	99966	59749	40251	00034	40285	44
17	60033	99966	60068	39932	00034	39967	43
18	60349	99965	60384	39616	00035	39651	42
19	60662	99964	60698	39302	00036	39338	41
20	8.60973	9.99964	8.61009	11.38991	10.00036	11.39027	40
21	61282	99963	61319	38681	00037	38718	39
22	61589	99963	61626	38374	00037	38411	38
23	61894	99962	61931	38069	00038	38106	37
24	62196	99962	62234	37766	00038	37804	36
25	62497	99961	62535	37465	00039	37503	35
26	62795	99961	62834	37166	00039	37205	34
27	63091	99960	63131	36869	00040	36909	33
28	63385	99960	63426	36574	00040	36615	32
29	63678	99959	63718	36282	00041	36322	31
30	8.63968	9.99959	8.64009	11.35991	10.00041	11.36032	30
31	64256	99958	64298	35702	00042	35744	29
32	64543	99958	64585	35415	00042	35457	28
33	64827	99957	64870	35130	00043	35173	27
34	65110	99956	65154	34846	00044	34890	26
35	65391	99956	65435	34565	00044	34609	25
36	65670	99955	65715	34285	00045	34330	24
37	65947	99955	65993	34007	00045	34053	23
38	66223	99954	66269	33731	00046	33777	22
39	66497	99954	66543	33457	00046	33503	21
40	8.66769	9.99953	8.66816	11.33184	10.00047	11.33231	20
41	67039	99952	67087	32913	00048	32961	19
42	67308	99952	67356	32644	00048	32692	18
43	67575	99951	67624	32376	00049	32425	17
44	67841	99951	67890	32110	00049	32159	16
45	68104	99950	68154	31846	00050	31896	15
46	68367	99949	68417	31583	00051	31633	14
47	68627	99949	68678	31322	00051	31373	13
48	68886	99948	68938	31062	00052	31114	12
49	69144	99948	69196	30804	00052	30856	11
50	8.69400	9.99947	8.69453	11.30547	10.00053	11.30600	10
51	69654	99946	69708	30292	00054	30346	9
52	69907	99946	69962	30038	00054	30093	8
53	70159	99945	70214	29786	00055	29841	7
54	70409	99944	70465	29535	00056	29591	6
55	70658	99944	70714	29286	00056	29342	5
56	70905	99943	70962	29038	00057	29095	4
57	71151	99942	71208	28792	00058	28849	3
58	71395	99942	71453	28547	00058	28605	2
59	71638	99941	71697	28303	00059	28362	1
60	71880	99940	71940	28060	00060	28120	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

87 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	8.71880	9.99940	8.71940	11.28060	10.00060	11.28120	60
1	72120	99940	72181	27819	00060	27880	59
2	72359	99939	72420	27580	00061	27641	58
3	72597	99938	72659	27341	00062	27403	57
4	72834	99938	72896	27104	00062	27166	56
5	73069	99937	73132	26868	00063	26931	55
6	73303	99936	73366	26634	00064	26697	54
7	73535	99936	73600	26400	00064	26465	53
8	73767	99935	73832	26168	00065	26233	52
9	73997	99934	74063	25937	00066	26003	51
10	8.74226	9.99934	8.74292	11.25708	10.00066	11.25774	50
11	74454	99933	74521	25479	00067	25546	49
12	74680	99932	74748	25252	00068	25320	48
13	74906	99932	74974	25026	00068	25094	47
14	75130	99931	75199	24801	00069	24870	46
15	75353	99930	75423	24577	00070	24647	45
16	75575	99929	75645	24355	00071	24425	44
17	75795	99929	75867	24133	00071	24205	43
18	76015	99928	76087	23913	00072	23985	42
19	76234	99927	76306	23694	00073	23766	41
20	8.76451	9.99926	8.76525	11.23475	10.00074	11.23549	40
21	76667	99926	76742	23258	00074	23333	39
22	76883	99925	76958	23042	00075	23117	38
23	77097	99924	77173	22827	00076	22903	37
24	77310	99923	77387	22613	00077	22690	36
25	77522	99923	77600	22400	00077	22478	35
26	77733	99922	77811	22189	00078	22267	34
27	77943	99921	78022	21978	00079	22057	33
28	78152	99920	78232	21768	00080	21848	32
29	78360	99920	78441	21559	00080	21640	31
30	8.78568	9.99919	8.78649	11.21351	10.00081	11.21432	30
31	78774	99918	78855	21145	00082	21226	29
32	78979	99917	79061	20939	00083	21021	28
33	79183	99917	79266	20734	00083	20817	27
34	79386	99916	79470	20530	00084	20614	26
35	79588	99915	79673	20327	00085	20412	25
36	79789	99914	79875	20125	00086	20211	24
37	79990	99913	80076	19924	00087	20010	23
38	80189	99913	80277	19723	00087	19811	22
39	80388	99912	80476	19524	00088	19612	21
40	8.80585	9.99911	8.80674	11.19326	10.00089	11.19415	20
41	80782	99910	80872	19128	00090	19218	19
42	80978	99909	81068	18932	00091	19022	18
43	81173	99909	81264	18736	00091	18827	17
44	81367	99908	81459	18541	00092	18633	16
45	81560	99907	81653	18347	00093	18440	15
46	81752	99906	81846	18154	00094	18248	14
47	81944	99905	82038	17962	00095	18056	13
48	82134	99904	82230	17770	00096	17866	12
49	82324	99904	82420	17580	00096	17676	11
50	8.82513	9.99903	8.82610	11.17390	10.00097	11.17487	10
51	82701	99902	82799	17201	00098	17299	9
52	82888	99901	82987	17013	00099	17112	8
53	83075	99900	83175	16825	00100	16925	7
54	83261	99899	83361	16639	00101	16739	6
55	83446	99898	83547	16453	00102	16554	5
56	83630	99898	83732	16268	00102	16370	4
57	83813	99897	83916	16084	00103	16187	3
58	83996	99896	84100	15900	00104	16004	2
59	84177	99895	84282	15718	00105	15823	1
60	84358	99894	84464	15536	00106	15642	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

86 Degrees.

Artificial Sines, Tang. and Sec. 4 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	8.84358	9.99894	8.84464	11.15536	10.00106	11.15642	60
1	84539	99893	84646	15354	00107	15461	59
2	84718	99892	84826	15174	00108	15282	58
3	84897	99891	85006	14994	00109	15103	57
4	85075	99891	85185	14815	00109	14925	56
5	85252	99890	85363	14637	00110	14748	55
6	85429	99889	85540	14460	00111	14571	54
7	85605	99888	85717	14283	00112	14395	53
8	85780	99887	85893	14107	00113	14220	52
9	85955	99886	86069	13931	00114	14045	51
10	8.86128	9.99885	8.86243	11.13757	10.00115	11.13872	50
11	86301	99884	86417	13583	00116	13699	49
12	86474	99883	86591	13409	00117	13526	48
13	86645	99882	86763	13237	00118	13355	47
14	86816	99881	86935	13065	00119	13184	46
15	86987	99880	87106	12894	00120	13013	45
16	87156	99879	87277	12723	00121	12844	44
17	87325	99879	87447	12553	00121	12675	43
18	87494	99878	87616	12384	00122	12506	42
19	87661	99877	87785	12215	00123	12339	41
20	8.87829	9.99876	8.87953	11.12047	10.00124	11.12171	40
21	87995	99875	88120	11880	00125	12005	39
22	88161	99874	88287	11713	00126	11839	38
23	88326	99873	88453	11547	00127	11674	37
24	88490	99872	88618	11382	00128	11510	36
25	88654	99871	88783	11217	00129	11346	35
26	88817	99870	88948	11052	00130	11183	34
27	88980	99869	89111	10889	00131	11020	33
28	89142	99868	89274	10726	00132	10858	32
29	89304	99867	89437	10563	00133	10696	31
30	8.89464	9.99866	8.89598	11.10402	10.00134	11.10536	30
31	89625	99865	89760	10240	00135	10375	29
32	89784	99864	89920	10080	00136	10216	28
33	89943	99863	90080	09920	00137	10057	27
34	90102	99862	90240	09760	00138	09898	26
35	90260	99861	90399	09601	00139	09740	25
36	90417	99860	90557	09443	00140	09583	24
37	90574	99859	90715	09285	00141	09426	23
38	90730	99858	90872	09128	00142	09270	22
39	90885	99857	91029	08971	00143	09115	21
40	8.91040	9.99856	8.91185	11.08815	10.00144	11.08960	20
41	91195	99855	91340	08660	00145	08805	19
42	91349	99854	91495	08505	00146	08651	18
43	91502	99853	91650	08350	00147	08498	17
44	91655	99852	91803	08197	00148	08345	16
45	91807	99851	91957	08043	00149	08193	15
46	91959	99850	92110	07890	00150	08041	14
47	92110	99848	92262	07738	00152	07890	13
48	92261	99847	92414	07586	00153	07739	12
49	92411	99846	92565	07435	00154	07589	11
50	8.92561	9.99845	8.92716	11.07284	10.00155	11.07439	10
51	92710	99844	92866	07134	00156	07290	9
52	92859	99843	93016	06984	00157	07141	8
53	93007	99842	93165	06835	00158	06993	7
54	93154	99841	93313	06687	00159	06846	6
55	93301	99840	93462	06538	00160	06699	5
56	93448	99839	93609	06391	00161	06552	4
57	93594	99838	93756	06244	00162	06406	3
58	93740	99837	93903	06097	00163	06260	2
59	93885	99836	94049	05951	00164	06115	1
60	94030	99834	94195	05805	00166	05970	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

85 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	8.94030	9.99834	8.94195	11.05805	10.00166	11.05970	60
1	94174	99833	94340	05660	00167	05826	59
2	94317	99832	94485	05515	00168	05683	58
3	94461	99831	94630	05370	00169	05539	57
4	94603	99830	94773	05227	00170	05397	56
5	94746	99829	94917	05083	00171	05254	55
6	94887	99828	95060	04940	00172	05113	54
7	95029	99827	95202	04798	00173	04971	53
8	95170	99825	95344	04656	00175	04830	52
9	95310	99824	95486	04514	00176	04690	51
10	8.95450	9.99823	8.95627	11.04373	10.00177	11.04550	50
11	95589	99822	95767	04233	00178	04411	49
12	95728	99821	95908	04092	00179	04272	48
13	95867	99820	96047	03953	00180	04133	47
14	96005	99819	96187	03813	00181	03995	46
15	96143	99817	96325	03675	00183	03857	45
16	96280	99816	96464	03536	00184	03720	44
17	96417	99815	96602	03398	00185	03583	43
18	96553	99814	96739	03261	00186	03447	42
19	96689	99813	96877	03123	00187	03311	41
20	8.96825	9.99812	8.97013	11.02987	10.00188	11.03175	40
21	96960	99810	97150	02850	00190	03040	39
22	97095	99809	97285	02715	00191	02905	38
23	97229	99808	97421	02579	00192	02771	37
24	97363	99807	97556	02444	00193	02637	36
25	97496	99806	97691	02309	00194	02504	35
26	97629	99804	97825	02175	00196	02371	34
27	97762	99803	97959	02041	00197	02238	33
28	97894	99802	98092	01908	00198	02106	32
29	98026	99801	98225	01775	00199	01974	31
30	8.98157	9.99800	8.98358	11.01642	10.00200	11.01843	30
31	98288	99798	98490	01510	00202	01712	29
32	98419	99797	98622	01378	00203	01581	28
33	98549	99796	98753	01247	00204	01451	27
34	98679	99795	98884	01116	00205	01321	26
35	98808	99793	99015	00985	00207	01192	25
36	98937	99792	99145	00855	00208	01063	24
37	99066	99791	99275	00725	00209	00934	23
38	99194	99790	99405	00595	00210	00806	22
39	99322	99788	99534	00466	00212	00678	21
40	8.99450	9.99787	8.99662	11.00338	10.00213	11.00550	20
41	99577	99786	99791	00209	00214	00423	19
42	99704	99785	99919	00081	00215	00296	18
43	99830	99783	9.00046	10.99954	00217	00170	17
44	99956	99782	00174	99826	00218	00044	16
45	9.00082	99781	00301	99699	00219	10.99918	15
46	00207	99780	00427	99573	00220	99793	14
47	00332	99778	00553	99447	00222	99668	13
48	00456	99777	00679	99321	00223	99544	12
49	00581	99776	00805	99195	00224	99419	11
50	9.00704	9.99775	9.00930	10.99070	10.00225	10.99296	10
51	00828	99773	01055	98945	00227	99172	9
52	00951	99772	01179	98821	00228	99049	8
53	01074	99771	01303	98697	00229	98926	7
54	01196	99769	01427	98573	00231	98804	6
55	01318	99768	01550	98450	00232	98682	5
56	01440	99767	01673	98327	00233	98560	4
57	01561	99765	01796	98204	00235	98439	3
58	01682	99764	01918	98082	00236	98318	2
59	01803	99763	02040	97960	00237	98197	1
60	01923	99761	02162	97838	00239	98077	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

Artificial Sines, Tang. and Sec. 6 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.01923	9.99761	9.02162	10.97838	10.00239	10.98077	60
1	02043	99760	02283	97717	00240	97957	59
2	02163	99759	02404	97596	00241	97837	58
3	02283	99757	02525	97475	00243	[illegible]	57
4	02402	99756	02645	97355	00244	97598	56
5	02520	99755	02766	97234	00245	97480	55
6	02639	99753	02885	97115	00247	97361	54
7	02757	99752	03005	96995	00248	97243	53
8	02874	99751	03124	96876	00249	97126	52
9	02992	99749	03242	96758	00251	97008	51
10	9.03109	9.99748	9.03361	10.96639	10.00252	10.96891	50
11	03226	99747	03479	96521	00253	96774	49
12	03342	99745	03597	96403	00255	96658	48
13	03458	99744	03714	96286	00256	96542	47
14	03574	99742	03832	96168	00258	96426	46
15	03690	99741	03948	96052	00259	96310	45
16	03805	99740	04065	95935	00260	96195	44
17	03920	99738	04181	95819	00262	96080	43
18	04034	99737	04297	95703	00263	95966	42
19	04149	99736	04413	95587	00264	95851	41
20	9.04262	9.99734	9.04528	10.95472	10.00266	10.95738	40
21	04376	99733	04643	95357	00267	95624	39
22	04490	99731	04758	95242	00269	95510	38
23	04603	99730	04873	95127	00270	95397	37
24	04715	99728	04987	95013	00272	95285	36
25	04828	99727	05101	94899	00273	95172	35
26	04940	99726	05214	94786	00274	95060	34
27	05052	99724	05328	94672	00276	94948	33
28	05164	99723	05441	94559	00277	94836	32
29	05275	99721	05553	94447	00279	94725	31
30	9.05386	9.99720	9.05666	10.94334	10.00280	10.94614	30
31	05497	99718	05778	94222	00282	94503	29
32	05607	99717	05890	94110	00283	94393	28
33	05717	99716	06002	93998	00284	94283	27
34	05827	99714	06113	93887	00286	94173	26
35	05937	99713	06224	93776	00287	94063	25
36	06046	99711	06335	93665	00289	93954	24
37	06155	99710	06445	93555	00290	93845	23
38	06264	99708	06556	93444	00292	93736	22
39	06372	99707	06666	93334	00293	93628	21
40	9.06481	9.99705	9.06775	10.93225	10.00295	10.93519	20
41	06589	99704	06885	93115	00296	93411	19
42	06696	99702	06994	93006	00298	93304	18
43	06804	99701	07103	92897	00299	93196	17
44	06911	99699	07211	92789	00301	93089	16
45	07018	99698	07320	92680	00302	92982	15
46	07124	99696	07428	92572	00304	92876	14
47	07231	99695	07536	92464	00305	92769	13
48	07337	99693	07643	92357	00307	92663	12
49	07442	99692	07751	92249	00308	92558	11
50	9.07548	9.99690	9.07858	10.92142	10.00310	10.92452	10
51	07653	99689	07964	92036	00311	92347	9
52	07758	99687	08071	91929	00313	92242	8
53	07863	99686	08177	91823	00314	92137	7
54	07968	99684	08283	91717	00316	92032	6
55	08072	99683	08389	91611	00317	91928	5
56	08176	99681	08495	91505	00319	91824	4
57	08280	99680	08600	91400	00320	91720	3
58	08383	99678	08705	91295	00322	91617	2
59	08486	99677	08810	91190	00323	91514	1
60	08589	99675	08914	91086	00325	91411	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

83 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.08589	9.99675	9.08914	10.91086	10.00325	10.91411	60
1	08692	99674	09019	90981	00326	91308	59
2	08795	99672	09123	90877	00328	91205	58
3	08897	99670	09227	90773	00330	91103	57
4	08999	99669	09330	90670	00331	91001	56
5	09101	99667	09434	90566	00333	90899	55
6	09202	99666	09537	90463	00334	90798	54
7	09304	99664	09640	90360	00336	90696	53
8	09405	99663	09742	90258	00337	90595	52
9	09506	99661	09845	90155	00339	90494	51
10	9.09606	9.99659	9.09947	10.90053	10.00341	10.90394	50
11	09707	99658	10049	89951	00342	90293	49
12	09807	99656	10150	89850	00344	90193	48
13	09907	99655	10252	89748	00345	90093	47
14	10006	99653	10353	89647	00347	89994	46
15	10106	99651	10454	89546	00349	89894	45
16	10205	99650	10555	89445	00350	89795	44
17	10304	99648	10656	89344	00352	89696	43
18	10402	99647	10756	89244	00353	89598	42
19	10501	99645	10856	89144	00355	89499	41
20	9.10599	9.99643	9.10956	10.89044	10.00357	10.89401	40
21	10697	99642	11056	88944	00358	89303	39
22	10795	99640	11155	88845	00360	89205	38
23	10893	99638	11254	88746	00362	89107	37
24	10990	99637	11353	88647	00363	89010	36
25	11087	99635	11452	88548	00365	88913	35
26	11184	99633	11551	88449	00367	88816	34
27	11281	99632	11649	88351	00368	88719	33
28	11377	99630	11747	88253	00370	88623	32
29	11474	99629	11845	88155	00371	88526	31
30	9.11570	9.99627	9.11943	10.88057	10.00373	10.88430	30
31	11666	99625	12040	87960	00375	88334	29
32	11761	99624	12138	87862	00376	88239	28
33	11857	99622	12235	87765	00378	88143	27
34	11952	99620	12332	87668	00380	88048	26
35	12047	99618	12428	87572	00382	87953	25
36	12142	99617	12525	87475	00383	87858	24
37	12236	99615	12621	87379	00385	87764	23
38	12331	99613	12717	87283	00387	87669	22
39	12425	99612	12813	87187	00388	87575	21
40	9.12519	9.99610	9.12909	10.87091	10.00390	10.87481	20
41	12612	99608	13004	86996	00392	87388	19
42	12706	99607	13099	86901	00393	87294	18
43	12799	99605	13194	86806	00395	87201	17
44	12892	99603	13289	86711	00397	87108	16
45	12985	99601	13384	86616	00399	87015	15
46	13078	99600	13478	86522	00400	86922	14
47	13171	99598	13573	86427	00402	86829	13
48	13263	99596	13667	86333	00404	86737	12
49	13355	99595	13761	86239	00405	86645	11
50	9.13447	9.99593	9.13854	10.86146	10.00407	10.86553	10
51	13539	99591	13948	86052	00409	86461	9
52	13630	99589	14041	85959	00411	86370	8
53	13722	99588	14134	85866	00412	86278	7
54	13813	99586	14227	85773	00414	86187	6
55	13904	99584	14320	85680	00416	86096	5
56	13994	99582	14412	85588	00418	86006	4
57	14085	99581	14504	85496	00419	85915	3
58	14175	99579	14597	85403	00421	85825	2
59	14266	99577	14688	85312	00423	85734	1
60	14356	99575	14780	85220	00425	85644	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

82 Degrees

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.14356	9.99575	9.14780	10.85220	10.00425	10.85644	60
1	14445	99574	14872	85128	00426	85555	59
2	14535	99572	14963	85037	00428	85465	58
3	14624	99570	15054	84946	00430	85[illegible]6	57
4	14714	99568	15145	84855	00432	85286	56
5	14803	99566	15236	84764	00434	85197	55
6	14891	99565	15327	84673	00435	85109	54
7	14980	99563	15417	84583	00437	85020	53
8	15069	99561	15508	84492	00439	84931	52
9	15157	99559	15598	84402	00441	84843	51
10	9.15245	9.99557	9.15688	10.84312	10.00443	10.84755	50
11	15333	99556	15777	84223	00444	84667	49
12	15421	99554	15867	84133	00446	84579	48
13	15508	99552	15956	84044	00448	84492	47
14	15596	99550	16046	83954	00450	84404	46
15	15683	99548	16135	83865	00452	84317	45
16	15770	99546	16224	83776	00454	84230	44
17	15857	99545	16312	83688	00455	84143	43
18	15944	99543	16401	83599	00457	84056	42
19	16030	99541	16489	83511	00459	83970	41
20	9.16116	9.99539	9.16577	10.83423	10.00461	10.83884	40
21	16203	99537	16665	83335	00463	83797	39
22	16289	99535	16753	83247	00465	83711	38
23	16374	99533	16841	83159	00467	83626	37
24	16460	99532	16928	83072	00468	83540	36
25	16545	99530	17016	82984	00470	83455	35
26	16631	99528	17103	82897	00472	83369	34
27	16716	99526	17190	82810	00474	83284	33
28	16801	99524	17277	82723	00476	83199	32
29	16886	99522	17363	82637	00478	83114	31
30	9.16970	9.99520	9.17450	10.82550	10.00480	10.83030	30
31	17055	99518	17536	82464	00482	82945	29
32	17139	99517	17622	82378	00483	82861	28
33	17223	99515	17708	82292	00485	82777	27
34	17307	99513	17794	82206	00487	82693	26
35	17391	99511	17880	82120	00489	82609	25
36	17474	99509	17965	82035	00491	82526	24
37	17558	99507	18051	81949	00493	82442	23
38	17641	99505	18136	81864	00495	82359	22
39	17724	99503	18221	81779	00497	82276	21
40	9.17807	9.99501	9.18306	10.81694	10.00499	10.82193	20
41	17890	99499	18391	81609	00501	82110	19
42	17973	99497	18475	81525	00503	82027	18
43	18055	99495	18560	81440	00505	81945	17
44	18137	99494	18644	81356	00506	81863	16
45	18220	99492	18728	81272	00508	81780	15
46	18302	99490	18812	81188	00510	81698	14
47	18383	99488	18896	81104	00512	81617	13
48	18465	99486	18979	81021	00514	81535	12
49	18547	99484	19063	80937	00516	81453	11
50	9.18628	9.99482	9.19146	10.80854	10.00518	10.81372	10
51	18709	99480	19229	80771	00520	81291	9
52	18790	99478	19312	80688	00522	81210	8
53	18871	99476	19395	80605	00524	81129	7
54	18952	99474	19478	80522	00526	81048	6
55	19033	99472	19561	80439	00528	80967	5
56	19113	99470	19643	80357	00530	80887	4
57	19193	99468	19725	80275	00532	80807	3
58	19273	99466	19807	80193	00534	80727	2
59	19353	99464	19889	80111	00536	80647	1
60	19433	99462	19971	80029	00538	80567	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

81 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.19433	9.99462	9.19971	10.80029	10.00538	10.80567	60
1	19513	99460	20053	79947	00540	80487	59
2	19592	99458	20134	79866	00542	80408	58
3	19672	99456	20216	79784	00544	80328	57
4	19751	99454	20297	79703	00546	80249	56
5	19830	99452	20378	79622	00548	80170	55
6	19909	99450	20459	79541	00550	80091	54
7	19988	99448	20540	79460	00552	80012	53
8	20067	99446	20621	79379	00554	79933	52
9	20145	99444	20701	79299	00556	79855	51
10	9.20223	9.99442	9.20782	10.79218	10.00558	10.79777	50
11	20302	99440	20862	79138	00560	79698	49
12	20380	99438	20942	79058	00562	79620	48
13	20458	99436	21022	78978	00564	79542	47
14	20535	99434	21102	78898	00566	79465	46
15	20613	99432	21182	78818	00568	79387	45
16	20691	99429	21261	78739	00571	79309	44
17	20768	99427	21341	78659	00573	79232	43
18	20845	99425	21420	78580	00575	79155	42
19	20922	99423	21499	78501	00577	79078	41
20	9.20999	9.99421	9.21578	10.78422	10.00579	10.79001	40
21	21076	99419	21657	78343	00581	78924	39
22	21153	99417	21736	78264	00583	78847	38
23	21229	99415	21814	78186	00585	78771	37
24	21306	99413	21893	78107	00587	78694	36
25	21382	99411	21971	78029	00589	78618	35
26	21458	99409	22049	77951	00591	78542	34
27	21534	99407	22127	77873	00593	78466	33
28	21610	99404	22205	77795	00596	78390	32
29	21685	99402	22283	77717	00598	78315	31
30	9.21761	9.99400	9.22361	10.77639	10.00600	10.78239	30
31	21836	99398	22438	77562	00602	78164	29
32	21912	99396	22516	77484	00604	78088	28
33	21987	99394	22593	77407	00606	78013	27
34	22062	99392	22670	77330	00608	77938	26
35	22137	99390	22747	77253	00610	77863	25
36	22211	99388	22824	77176	00612	77789	24
37	22286	99385	22901	77099	00615	77714	23
38	22361	99383	22977	77023	00617	77639	22
39	22435	99381	23054	76946	00619	77565	21
40	9.22509	9.99379	9.23130	10.76870	10.00621	10.77491	20
41	22583	99377	23206	76794	00623	77417	19
42	22657	99375	23283	76717	00625	77343	18
43	22731	99372	23359	76641	00628	77269	17
44	22805	99370	23435	76565	00630	77195	16
45	22878	99368	23510	76490	00632	77122	15
46	22952	99366	23586	76414	00634	77048	14
47	23025	99364	23661	76339	00636	76975	13
48	23098	99362	23737	76263	00638	76902	12
49	23171	99359	23812	76188	00641	76829	11
50	9.23244	9.99357	9.23887	10.76113	10.00643	10.76756	10
51	23317	99355	23962	76038	00645	76683	9
52	23390	99353	24037	75963	00647	76610	8
53	23462	99351	24112	75888	00649	76538	7
54	23535	99348	24186	75814	00652	76465	6
55	23607	99346	24261	75739	00654	76393	5
56	23679	99344	24335	75665	00656	76321	4
57	23752	99342	24410	75590	00658	76248	3
58	23823	99340	24484	75516	00660	76177	2
59	23895	99337	24558	75442	00663	76105	1
60	23967	99335	24632	75368	00665	76033	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.23967	9.99335	9.24632	10.75368	10.00665	10.76033	60
1	24039	99333	24706	75294	00667	75961	59
2	24110	99331	24779	75221	00669	75890	58
3	24181	99328	24853	75147	00672	75819	57
4	24253	99326	24926	75074	00674	75747	56
5	24324	99324	25000	75000	00676	75676	55
6	24395	99322	25073	74927	00678	75605	54
7	24466	99319	25146	74854	00681	75534	53
8	24536	99317	25219	74781	00683	75464	52
9	24607	99315	25292	74708	00685	75393	51
10	9.24677	9.99313	9.25365	10.74635	10.00687	10.75323	50
11	24748	99310	25437	74563	00690	75252	49
12	24818	99308	25510	74490	00692	75182	48
13	24888	99306	25582	74418	00694	75112	47
14	24958	99304	25655	74345	00696	75042	46
15	25028	99301	25727	74273	00699	74972	45
16	25098	99299	25799	74201	00701	74902	44
17	25168	99297	25871	74129	00703	74832	43
18	25237	99294	25943	74057	00706	74763	42
19	25307	99292	26015	73985	00708	74693	41
20	9.25376	9.99290	9.26086	10.73914	10.00710	10.74624	40
21	25445	99288	26158	73842	00712	74555	39
22	25514	99285	26229	73771	00715	74486	38
23	25583	99283	26301	73699	00717	74417	37
24	25652	99281	26372	73628	00719	74348	36
25	25721	99278	26443	73557	00722	74279	35
26	25790	99276	26514	73486	00724	74210	34
27	25858	99274	26585	73415	00726	74142	33
28	25927	99271	26655	73345	00729	74073	32
29	25995	99269	26726	73274	00731	74005	31
30	9.26063	9.99267	9.26797	10.73203	10.00733	10.73937	30
31	26131	99264	26867	73133	00736	73869	29
32	26199	99262	26937	73063	00738	73801	28
33	26267	99260	27008	72992	00740	73733	27
34	26335	99257	27078	72922	00743	73665	26
35	26403	99255	27148	72852	00745	73597	25
36	26470	99252	27218	72782	00748	73530	24
37	26538	99250	27288	72712	00750	73462	23
38	26605	99248	27357	72643	00752	73395	22
39	26672	99245	27427	72573	00755	73328	21
40	9.26739	9.99243	9.27496	10.72504	10.00757	10.73261	20
41	26806	99241	27566	72434	00759	73194	19
42	26873	99238	27635	72365	00762	73127	18
43	26940	99236	27704	72296	00764	73060	17
44	27007	99233	27773	72227	00767	72993	16
45	27073	99231	27842	72158	00769	72927	15
46	27140	99229	27911	72089	00771	72860	14
47	27206	99226	27980	72020	00774	72794	13
48	27273	99224	28049	71951	00776	72727	12
49	27339	99221	28117	71883	00779	72661	11
50	9.27405	9.99219	9.28186	10.71814	10.00781	10.72595	10
51	27471	99217	28254	71746	00783	72529	9
52	27537	99214	28323	71677	00786	72463	8
53	27602	99212	28391	71609	00788	72398	7
54	27668	99209	28459	71541	00791	72332	6
55	27734	99207	28527	71473	00793	72266	5
56	27799	99204	28595	71405	00796	72201	4
57	27864	99202	28662	71338	00798	72136	3
58	27930	99200	28730	71270	00800	72070	2
59	27995	99197	28798	71202	00803	72005	1
60	28060	99195	28865	71135	00805	71940	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

79 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.28060	9.99195	9.28865	10.71135	10.00805	10.71940	60
1	28125	99192	28933	71067	00808	71875	59
2	28190	99190	29000	71000	00810	71810	58
3	28254	99187	29067	70933	00813	71746	57
4	28319	99185	29134	70866	00815	71681	56
5	28384	99182	29201	70799	00818	71616	55
6	28448	99180	29268	70732	00820	71552	54
7	28512	99177	29335	70665	00823	71488	53
8	28577	99175	29402	70598	00825	71423	52
9	28641	99172	29468	70532	00828	71359	51
10	9.28705	9.99170	9.29535	10.70465	10.00830	10.71295	50
11	28769	99167	29601	70399	00833	71231	49
12	28833	99165	29668	70332	00835	71167	48
13	28896	99162	29734	70266	00838	71101	47
14	28960	99160	29800	70200	00840	71040	46
15	29024	99157	29866	70134	00843	70976	45
16	29087	99155	29932	70068	00845	70913	44
17	29150	99152	29998	70002	00848	70850	43
18	29214	99150	30064	69936	00850	70786	42
19	29277	99147	30130	69870	00853	70723	41
20	9.29340	9.99145	9.30195	10.69805	10.00855	10.70660	40
21	29403	99142	30261	69739	00858	70597	39
22	29466	99140	30326	69674	00860	70534	38
23	29529	99137	30391	69609	00863	70471	37
24	29591	99135	30457	69543	00865	70409	36
25	29654	99132	30522	69478	00868	70346	35
26	29716	99130	30587	69413	00870	70284	34
27	29779	99127	30652	69348	00873	70221	33
28	29841	99124	30717	69283	00876	70159	32
29	29903	99122	30782	69218	00878	70097	31
30	9.29966	9.99119	9.30846	10.69154	10.00881	10.70034	30
31	30028	99117	30911	69089	00883	69972	29
32	30090	99114	30975	69025	00886	69910	28
33	30151	99112	31040	68960	00888	69849	27
34	30213	99109	31104	68896	00891	69787	26
35	30275	99106	31168	68832	00894	69725	25
36	30336	99104	31233	68767	00896	69664	24
37	30398	99101	31297	68703	00899	69602	23
38	30459	99099	31361	68639	00901	69541	22
39	30521	99096	31425	68575	00904	69479	21
40	9.30582	9.99093	9.31489	10.68511	10.00907	10.69418	20
41	30643	99091	31552	68448	00909	69357	19
42	30704	99088	31616	68384	00912	69296	18
43	30765	99086	31679	68321	00914	69235	17
44	30826	99083	31743	68257	00917	69174	16
45	30887	99080	31806	68194	00920	69113	15
46	30947	99078	31870	68130	00922	69053	14
47	31008	99075	31933	68067	00925	68992	13
48	31068	99072	31996	68004	00928	68932	12
49	31129	99070	32059	67941	00930	68871	11
50	9.31189	9.99067	9.32122	10.67878	10.00933	10.68811	10
51	31250	99064	32185	67815	00936	68750	9
52	31310	99062	32248	67752	00938	68690	8
53	31370	99059	32311	67689	00941	68630	7
54	31430	99056	32373	67627	00944	68570	6
55	31490	99054	32436	67564	00946	68510	5
56	31549	99051	32498	67502	00949	68451	4
57	31609	99048	32561	67439	00952	68391	3
58	31669	99046	32623	67377	00954	68331	2
59	31728	99043	32685	67315	00957	68272	1
60	31788	99040	32747	67253	00960	68212	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.31788	9.99040	9.32747	10.67253	10.00960	10.68212	60
1	31847	99038	32810	67190	00962	68153	59
2	31907	99035	32872	67128	00965	68093	58
3	31966	99032	32933	67067	00968	68034	57
4	32025	99030	32995	67005	00970	67975	56
5	32084	99027	33057	66943	00973	67916	55
6	32143	99024	33119	66881	00976	67857	54
7	32202	99022	33180	66820	00978	67798	53
8	32261	99019	33242	66758	00981	67739	52
9	32319	99016	33303	66697	00984	67681	51
10	9.32378	9.99013	9.33365	10.66635	10.00987	10.67622	50
11	32437	99011	33426	66574	00989	67563	49
12	32495	99008	33487	66513	00992	67505	48
13	32553	99005	33548	66452	00995	67447	47
14	32612	99002	33609	66391	00998	67388	46
15	32670	99000	33670	66330	01000	67330	45
16	32728	98997	33731	66269	01003	67272	44
17	32786	98994	33792	66208	01006	67214	43
18	32844	98991	33853	66147	01009	67156	42
19	32902	98989	33913	66087	01011	67098	41
20	9.32960	9.98986	9.33974	10.66026	10.01014	10.67040	40
21	33018	98983	34034	65966	01017	66982	39
22	33075	98980	34095	65905	01020	66925	38
23	33133	98978	34155	65845	01022	66867	37
24	33190	98975	34215	65785	01025	66810	36
25	33248	98972	34276	65724	01028	66752	35
26	33305	98969	34336	65664	01031	66695	34
27	33362	98967	34396	65604	01033	66638	33
28	33420	98964	34456	65544	01036	66580	32
29	33477	98961	34516	65484	01039	66523	31
30	9.33534	9.98958	9.34576	10.65424	10.01042	10.66466	30
31	33591	98955	34635	65365	01045	66409	29
32	33647	98953	34695	65305	01047	66353	28
33	33704	98950	34755	65245	01050	66296	27
34	33761	98947	34814	65186	01053	66239	26
35	33818	98944	34874	65126	01056	66182	25
36	33874	98941	34933	65067	01059	66126	24
37	33931	98938	34992	65008	01062	66069	23
38	33987	98936	35051	64949	01064	66013	22
39	34043	98933	35111	64889	01067	65957	21
40	9.34100	9.98930	9.35170	10.64830	10.01070	10.65900	20
41	34156	98927	35229	64771	01073	65844	19
42	34212	98924	35288	64712	01076	65788	18
43	34268	98921	35347	64653	01079	65732	17
44	34324	98919	35405	64595	01081	65676	16
45	34380	98916	35464	64536	01084	65620	15
46	34436	98913	35523	64477	01087	65564	14
47	34491	98910	35581	64419	01090	65509	13
48	34547	98907	35640	64360	01093	65453	12
49	34602	98904	35698	64302	01096	65398	11
50	9.34658	9.98901	9.35757	10.64243	10.01099	10.65342	10
51	34713	98898	35815	64185	01102	65287	9
52	34769	98896	25873	64127	01104	65231	8
53	34824	98893	35931	64069	01107	65176	7
54	34879	98890	35989	64011	01110	65121	6
55	34934	98887	36047	63953	01113	65066	5
56	34989	98884	36105	63895	01116	65011	4
57	35044	98881	36163	63837	01119	64956	3
58	35099	98878	36221	63779	01122	64901	2
59	35154	98875	36279	63721	01125	64846	1
60	35209	98872	36336	63664	01128	64791	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

77 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.35209	9.98872	9.36336	10.63664	10.01128	10.64791	60
1	35263	98869	36394	63606	01131	64737	59
2	35318	98867	36452	63548	01133	64682	58
3	35373	98864	36509	63491	01136	64627	57
4	35427	98861	36566	63434	01139	64573	56
5	35481	98858	36624	63376	01142	64519	55
6	35536	98855	36681	63319	01145	64464	54
7	35590	98852	36738	63262	01148	64410	53
8	35644	98849	36795	63205	01151	64356	52
9	35698	98846	36852	63148	01154	64302	51
10	9.35752	9.98843	9.36909	10.63091	10.01157	10.64248	50
11	35806	98840	36966	63034	01160	64194	49
12	35860	98837	37023	62977	01163	64140	48
13	35914	98834	37080	62920	01166	64086	47
14	35968	98831	37137	62863	01169	64032	46
15	36022	98828	37193	62807	01172	63978	45
16	36075	98825	37250	62750	01175	63925	44
17	36129	98822	37306	62694	01178	63871	43
18	36182	98819	37363	62637	01181	63818	42
19	36236	98816	37419	62581	01184	63764	41
20	9.36289	9.98813	9.37476	10.62524	10.01187	10.63711	40
21	36342	98810	37532	62468	01190	63658	39
22	36395	98807	37588	62412	01193	63605	38
23	36449	98804	37644	62356	01196	63551	37
24	36502	98801	37700	62300	01199	63498	36
25	36555	98798	37756	62244	01202	63445	35
26	36608	98795	37812	62188	01205	63392	34
27	36660	98792	37868	62132	01208	63340	33
28	36713	98789	37924	62076	01211	63287	32
29	36766	98786	37980	62020	01214	63234	31
30	9.36819	9.98783	9.38035	10.61965	10.01217	10.63181	30
31	36871	98780	38091	61909	01220	63129	29
32	36924	98777	38147	61853	01223	63076	28
33	36976	98774	38202	61798	01226	63024	27
34	37028	98771	38257	61743	01229	62972	26
35	37081	98768	38313	61687	01232	62919	25
36	37133	98765	38368	61632	01235	62867	24
37	37185	98762	38423	61577	01238	62815	23
38	37237	98759	38479	61521	01241	62763	22
39	37289	98756	38534	61466	01244	62711	21
40	9.37341	9.98753	9.38589	10.61411	10.01247	10.62659	20
41	37393	98750	38644	61356	01250	62607	19
42	37445	98746	38699	61301	01254	62555	18
43	37497	98743	38754	61246	01257	62503	17
44	37549	98740	38808	61192	01260	62451	16
45	37600	98737	38863	61137	01263	62400	15
46	37652	98734	38918	61082	01266	62348	14
47	37703	98731	38972	61028	01269	62297	13
48	37755	98728	39027	60973	01272	62245	12
49	37806	98725	39082	60918	01275	62194	11
50	9.37858	9.98722	9.39136	10.60864	10.01278	10.62142	10
51	37909	98719	39190	60810	01281	62091	9
52	37960	98715	39245	60755	01285	62040	8
53	38011	98712	39299	60701	01288	61989	7
54	38062	98709	39353	60647	01291	61938	6
55	38113	98706	39407	60593	01294	61887	5
56	38164	98703	39461	60539	01297	61836	4
57	38215	98700	39515	60485	01300	61785	3
58	38266	98697	39569	60431	01303	61734	2
59	38317	98694	39623	60377	01306	61683	1
60	38368	98690	39677	60323	01310	61632	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.38368	9.98690	9.39677	10.60323	10.01310	10.61632	60
1	38418	98687	39731	60269	01313	61582	59
2	38469	98684	39785	60215	01316	61531	58
3	38519	98681	39838	60162	01319	61481	57
4	38570	98678	39892	60108	01322	61430	56
5	38620	98675	39945	60055	01325	61380	55
6	38670	98671	39999	60001	01329	61330	54
7	38721	98668	40052	59948	01332	61279	53
8	38771	98665	40106	59894	01335	61229	52
9	38821	98662	40159	59841	01338	61179	51
10	9.38871	9.98659	9.40212	10.59788	10.01341	10.61129	50
11	38921	98656	40266	59734	01344	61079	49
12	38971	98652	40319	59681	01348	61029	48
13	39021	98649	40372	59628	01351	60979	47
14	39071	98646	40425	59575	01354	60929	46
15	39121	98643	40478	59522	01357	60879	45
16	39170	98640	40531	59469	01360	60830	44
17	39220	98636	40584	59416	01364	60780	43
18	39270	98633	40636	59364	01367	60730	42
19	39319	98630	40689	59311	01370	60681	41
20	9.39369	9.98627	9.40742	10.59258	10.01373	10.60631	40
21	39418	98623	40795	59205	01377	60582	39
22	39467	98620	40847	59153	01380	60533	38
23	39517	98617	40900	59100	01383	60483	37
24	39566	98614	40952	59048	01386	60434	36
25	39615	98610	41005	58995	01390	60385	35
26	39664	98607	41057	58943	01393	60336	34
27	39713	98604	41109	58891	01396	60287	33
28	39762	98601	41161	58839	01399	60238	32
29	39811	98597	41214	58786	01403	60189	31
30	9.39860	9.98594	9.41266	10.58734	10.01406	10.60140	30
31	39909	98591	41318	58682	01409	60091	29
32	39958	98588	41370	58630	01412	60042	28
33	40006	98584	41422	58578	01416	59994	27
34	40055	98581	41474	58526	01419	59945	26
35	40103	98578	41526	58474	01422	59897	25
36	40152	98574	41578	58422	01426	59848	24
37	40200	98571	41629	58371	01429	59800	23
38	40249	98568	41681	58319	01432	59751	22
39	40297	98565	41733	58267	01435	59703	21
40	9.40346	9.98561	9.41784	10.58216	10.01439	10.59654	20
41	40394	98558	41836	58164	01442	59606	19
42	40442	98555	41887	58113	01445	59558	18
43	40490	98551	41939	58061	01449	59510	17
44	40538	98548	41990	58010	01452	59462	16
45	40586	98545	42041	57959	01455	59414	15
46	40634	98541	42093	57907	01459	59366	14
47	40682	98538	42144	57856	01462	59318	13
48	40730	98535	42195	57805	01465	59270	12
49	40778	98531	42246	57754	01469	59222	11
50	9.40825	9.98528	9.42297	10.57703	10.01472	10.59175	10
51	40873	98525	42348	57652	01475	59127	9
52	40921	98521	42399	57601	01479	59079	8
53	40968	98518	42450	57550	01482	59032	7
54	41016	98515	42501	57499	01485	58984	6
55	41063	98511	42552	57448	01489	58937	5
56	41111	98508	42603	57397	01492	58889	4
57	41158	98505	42653	57347	01495	58842	3
58	41205	98501	42704	57296	01499	58795	2
59	41252	98498	42755	57245	01502	58748	1
60	41300	98494	42805	57195	01506	58700	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

75 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.41300	9.98494	9.42805	10.57195	10.01506	10.58700	60
1	41347	98491	42856	57144	01509	58653	59
2	41394	98488	42906	57094	01512	58606	58
3	41441	98484	42957	57043	01516	58559	57
4	41488	98481	43007	56993	01519	58512	56
5	41535	98477	43057	56943	01523	58465	55
6	41582	98474	43108	56892	01526	58418	54
7	41628	98471	43158	56842	01529	58372	53
8	41675	98467	43208	56792	01533	58325	52
9	41722	98464	43258	56742	01536	58278	51
10	9.41768	9.98460	9.43308	10.56692	10.01540	10.58232	50
11	41815	98457	43358	56642	01543	58185	49
12	41861	98453	43408	56592	01547	58139	48
13	41908	98450	43458	56542	01550	58092	47
14	41954	98447	43508	56492	01553	58046	46
15	42001	98443	43558	56442	01557	57999	45
16	42047	98440	43607	56393	01560	57953	44
17	42093	98436	43657	56343	01564	57907	43
18	42140	98433	43707	56293	01567	57860	42
19	42186	98429	43756	56244	01571	57814	41
20	9.42232	9.98426	9.43806	10.56194	10.01574	10.57768	40
21	42278	98422	43855	56145	01578	57722	39
22	42324	98419	43905	56095	01581	57676	38
23	42370	98415	43954	56046	01585	57630	37
24	42416	98412	44004	55996	01588	57584	36
25	42461	98409	44053	55947	01591	57539	35
26	42507	98405	44102	55898	01595	57493	34
27	42553	98402	44151	55849	01598	57447	33
28	42599	98398	44201	55799	01602	57401	32
29	42644	98395	44250	55750	01605	57356	31
30	9.42690	9.98391	9.44299	10.55701	10.01609	10.57310	30
31	42735	98388	44348	55652	01612	57265	29
32	42781	98384	44397	55603	01616	57219	28
33	42826	98381	44446	55554	01619	57174	27
34	42872	98377	44495	55505	01623	57128	26
35	42917	98373	44544	55456	01627	57083	25
36	42962	98370	44592	55408	01630	57038	24
37	43008	98366	44641	55359	01634	56992	23
38	43053	98363	44690	55310	01637	56947	22
39	43098	98359	44738	55262	01641	56902	21
40	9.43143	9.98356	9.44787	10.55213	10.01644	10.56857	20
41	43188	98352	44836	55164	01648	56812	19
42	43233	98349	44884	55116	01651	56767	18
43	43278	98345	44933	55067	01655	56722	17
44	43323	98342	44981	55019	01658	56677	16
45	43367	98338	45029	54971	01662	56633	15
46	43412	98334	45078	54922	01666	56588	14
47	43457	98331	45126	54874	01669	56543	13
48	43502	98327	45174	54826	01673	56498	12
49	43546	98324	45222	54778	01676	56454	11
50	9.43591	9.98320	9.45271	10.54729	10.01680	10.56409	10
51	43635	98317	45319	54681	01683	56365	9
52	43680	98313	45367	54633	01687	56320	8
53	43724	98309	45415	54585	01691	56276	7
54	43769	98306	45463	54537	01694	56231	6
55	43813	98302	45511	54489	01698	56187	5
56	43857	98299	45559	54441	01701	56143	4
57	43901	98295	45606	54394	01705	56099	3
58	43946	98291	45654	54346	01709	56054	2
59	43990	98288	45702	54298	01712	56010	1
60	44034	98284	45750	54250	01716	55966	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.44034	9.98284	9.45750	10.54250	10.01716	10.55966	60
1	44078	98281	45797	54203	01719	55922	59
2	44122	98277	45845	54155	01723	55878	58
3	44166	98273	45892	54108	01727	55834	57
4	44210	98270	45940	54060	01730	55790	56
5	44253	98266	45987	54013	01734	55747	55
6	44297	98262	46035	53965	01738	55703	54
7	44341	98259	46082	53918	01741	55659	53
8	44385	98255	46130	53870	01745	55615	52
9	44428	98251	46177	53823	01749	55572	51
10	9.44472	9.98248	9.46224	10.53776	10.01752	10.55528	50
11	44516	98244	46271	53729	01756	55484	49
12	44559	98240	46319	53681	01760	55441	48
13	44602	98237	46366	53634	01763	55398	47
14	44646	98233	46413	53587	01767	55354	46
15	44689	98229	46460	53540	01771	55311	45
16	44733	98226	46507	53493	01774	55267	44
17	44776	98222	46554	53446	01778	55224	43
18	44819	98218	46601	53399	01782	55181	42
19	44862	98215	46648	53352	01785	55138	41
20	9.44905	9.98211	9.46694	10.53306	10.01789	10.55095	40
21	44948	98207	46741	53259	01793	55052	39
22	44992	98204	46788	53212	01796	55003	38
23	45035	98200	46835	53165	01800	54965	37
24	45077	98196	46881	53119	01804	54923	36
25	45120	98192	46928	53072	01808	54880	35
26	45163	98189	46975	53025	01811	54837	34
27	45206	98185	47021	52979	01815	54794	33
28	45249	98181	47068	52932	01819	54751	32
29	45292	98177	47114	52886	01823	54708	31
30	9.45334	9.98174	9.47160	10.52840	10.01826	10.54666	30
31	45377	98170	47207	52793	01830	54623	29
32	45419	98166	47253	52747	01834	54581	28
33	45462	98162	47299	52701	01838	54538	27
34	45504	98159	47346	52654	01841	54496	26
35	45547	98155	47392	52608	01845	54453	25
36	45589	98151	47438	52562	01849	54411	24
37	45632	98147	47484	52516	01853	54368	23
38	45674	98144	47530	52470	01856	54326	22
39	45716	98140	47576	52424	01860	54284	21
40	9.45758	9.98136	9.47622	10.52378	10.01864	10.54242	20
41	45801	98132	47668	52332	01868	54199	19
42	45843	98129	47714	52286	01871	54157	18
43	45885	98125	47760	52240	01875	54115	17
44	45927	98121	47806	52194	01879	54073	16
45	45969	98117	47852	52148	01883	54031	15
46	46011	98113	47897	52103	01887	53989	14
47	46053	98110	47943	52057	01890	53947	13
48	46095	98106	47989	52011	01894	53905	12
49	46136	98102	48035	51965	01898	53864	11
50	9.46178	9.98098	9.48080	10.51920	10.01902	10.53822	10
51	46220	98094	48126	51874	01906	53780	9
52	46262	98090	48171	51829	01910	53738	8
53	46303	98087	48217	51783	01913	53697	7
54	46345	98083	48262	51738	01917	53655	6
55	46386	98079	48307	51693	01921	53614	5
56	46428	98075	48353	51647	01925	53572	4
57	46469	98071	48398	51602	01929	53531	3
58	46511	98067	48443	51557	01933	53489	2
59	46552	98063	48489	51511	01937	53448	1
60	46594	98060	48534	51466	01940	53406	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

73 Degrees

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.46594	9.98060	9.48534	10.51466	10.01940	10.53406	60
1	46635	98056	48579	51421	01944	53365	59
2	46676	98052	48624	51376	01948	53324	58
3	46717	98048	48669	51331	01952	53283	57
4	46758	98044	48714	51286	01956	53242	56
5	46800	98040	48759	51241	01960	53200	55
6	46841	98036	48804	51196	01964	53159	54
7	46882	98032	48849	51151	01968	53118	53
8	46923	98029	48894	51106	01971	53077	52
9	46964	98025	48939	51061	01975	53036	51
10	9.47005	9.98021	9.48984	10.51016	10.01979	10.52995	50
11	47045	98017	49029	50971	01983	52955	49
12	47086	98013	49073	50927	01987	52914	48
13	47127	98009	49118	50882	01991	52873	47
14	47168	98005	49163	50837	01995	52832	46
15	47209	98001	49207	50793	01999	52791	45
16	47249	97997	49252	50748	02003	52751	44
17	47290	97993	49296	50704	02007	52710	43
18	47330	97989	49341	50659	02011	52670	42
19	47371	97986	49385	50615	02014	52629	41
20	9.47411	9.97982	9.49430	10.50570	10.02018	10.52589	40
21	47452	97978	49474	50526	02022	52548	39
22	47492	97974	49519	50481	02026	52508	38
23	47533	97970	49563	50437	02030	52467	37
24	47573	97966	49607	50393	02034	52427	36
25	47613	97962	49652	50348	02038	52387	35
26	47654	97958	49696	50304	02042	52346	34
27	47694	97954	49740	50260	02046	52306	33
28	47734	97950	49784	50216	02050	52266	32
29	47774	97946	49828	50172	02054	52226	31
30	9.47814	9.97942	9.49872	10.50128	10.02058	10.52186	30
31	47854	97938	49916	50084	02062	52146	29
32	47894	97934	49960	50040	02066	52106	28
33	47934	97930	50004	49996	02070	52066	27
34	47974	97926	50048	49952	02074	52026	26
35	48014	97922	50092	49908	02078	51986	25
36	48054	97918	50136	49864	02082	51946	24
37	48094	97914	50180	49820	02086	51906	23
38	48133	97910	50223	49777	02090	51867	22
39	48173	97906	50267	49733	02094	51827	21
40	9.48213	9.97902	9.50311	10.49689	10.02098	10.51787	20
41	48252	97898	50355	49645	02102	51748	19
42	48292	97894	50398	49602	02106	51708	18
43	48332	97890	50442	49558	02110	51668	17
44	48371	97886	50485	49515	02114	51629	16
45	48411	97882	50529	49471	02118	51589	15
46	48450	97878	50572	49428	02122	51550	14
47	48490	97874	50616	49384	02126	51510	13
48	48529	97870	50659	49341	02130	51471	12
49	48568	97866	50703	49297	02134	51432	11
50	9.48607	9.97861	9.50746	10.49254	10.02139	10.51393	10
51	48647	97857	50789	49211	02143	51353	9
52	48686	97853	50833	49167	02147	51314	8
53	48725	97849	50876	49124	02151	51275	7
54	48764	97845	50919	49081	02155	51236	6
55	48803	97841	50962	49038	02159	51197	5
56	48842	97837	51005	48995	02163	51158	4
57	48881	97833	51048	48952	02167	51119	3
58	48920	97829	51092	48908	02171	51080	2
59	48959	97825	51135	48865	02175	51041	1
60	48998	97821	51178	48822	02179	51002	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

72 Degrees.

Artificial Sines, Tang. and Sec. 18 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.48998	9.97821	9.51178	10.48822	10.02179	10.51002	60
1	49037	97817	51221	48779	02183	50963	59
2	49076	97812	51264	48736	02188	50924	58
3	49115	97808	51306	48694	02192	50885	57
4	49153	97804	51349	48651	02196	50847	56
5	49192	97800	51392	48608	02200	50808	55
6	49231	97796	51435	48565	02204	50769	54
7	49269	97792	51478	48522	02208	50731	53
8	49308	97788	51520	48480	02212	50692	52
9	49347	97784	51563	48437	02216	50653	51
10	9.49385	9.97779	9.51606	10.48394	10.02221	10.50615	50
11	49424	97775	51648	48352	02225	50576	49
12	49462	97771	51691	48309	02229	50538	48
13	49500	97767	51734	48266	02233	50500	47
14	49539	97763	51776	48224	02237	50461	46
15	49577	97759	51819	48181	02241	50423	45
16	49615	97754	51861	48139	02246	50385	44
17	49654	97750	51903	48097	02250	50346	43
18	49692	97746	51946	48054	02254	50308	42
19	49730	97742	51988	48012	02258	50270	41
20	9.49768	9.97738	9.52031	10.47969	10.02262	10.50232	40
21	49806	97734	52073	47927	02266	50194	39
22	49844	97729	52115	47885	02271	50156	38
23	49882	97725	52157	47843	02275	50118	37
24	49920	97721	52200	47800	02279	50080	36
25	49958	97717	52242	47758	02283	50042	35
26	49996	97713	52284	47716	02287	50004	34
27	50034	97708	52326	47674	02292	49966	33
28	50072	97704	52368	47632	02296	49928	32
29	50110	97700	52410	47590	02300	49890	31
30	9.50148	9.97696	9.52452	10.47548	10.02304	10.49852	30
31	50185	97691	52494	47506	02309	49815	29
32	50223	97687	52536	47464	02313	49777	28
33	50261	97683	52578	47422	02317	49739	27
34	50298	97679	52620	47380	02321	49702	26
35	50336	97674	52661	47339	02326	49664	25
36	50374	97670	52703	47297	02330	49626	24
37	50411	97666	52745	47255	02334	49589	23
38	50449	97662	52787	47213	02338	49551	22
39	50486	97657	52829	47171	02343	49514	21
40	9.50523	9.97653	9.52870	10.47130	10.02347	10.49477	20
41	50561	97649	52912	47088	02351	49439	19
42	50598	97645	52953	47047	02355	49402	18
43	50635	97640	52995	47005	02360	49365	17
44	50673	97636	53037	46963	02364	49327	16
45	50710	97632	53078	46922	02368	49290	15
46	50747	97628	53120	46880	02372	49253	14
47	50784	97623	53161	46839	02377	49216	13
48	50821	97619	53202	46798	02381	49179	12
49	50858	97615	53244	46756	02385	49142	11
50	9.50896	9.97610	9.53285	10.46715	10.02390	10.49104	10
51	50933	97606	53327	46673	02394	49067	9
52	50970	97602	53368	46632	02398	49030	8
53	51007	97597	53409	46591	02403	48993	7
54	51043	97593	53450	46550	02407	48957	6
55	51080	97589	53492	46508	02411	48920	5
56	51117	97584	53533	46467	02416	48883	4
57	51154	97580	53574	46426	02420	48846	3
58	51191	97576	53615	46385	02424	48809	2
59	51227	97571	53656	46344	02429	48773	1
60	51264	97567	53697	46303	02433	48736	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

71 Degrees.

Artificial Sines, Tang. and Sec. 19 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.51264	9.97567	9.53697	10.46303	10.02433	10.48736	60
1	51301	97563	53738	46262	02437	48699	59
2	51338	97558	53779	46221	02442	48662	58
3	51374	97554	53820	46180	02446	48626	57
4	51411	97550	53861	46139	02450	48589	56
5	51447	97545	53902	46098	02455	48553	55
6	51484	97541	53943	46057	02459	48516	54
7	51520	97536	53984	46016	02464	48480	53
8	51557	97532	54025	45975	02468	48443	52
9	51593	97528	54065	45935	02472	48407	51
10	9.51629	9.97523	9.54106	10.45894	10.02477	10.48371	50
11	51666	97519	54147	45853	02481	48334	49
12	51702	97515	54187	45813	02485	48298	48
13	51738	97510	54228	45772	02490	48262	47
14	51774	97506	54269	45731	02494	48226	46
15	51811	97501	54309	45691	02499	48189	45
16	51847	97497	54350	45650	02503	48153	44
17	51883	97492	54390	45610	02508	48117	43
18	51919	97488	54431	45569	02512	48081	42
19	51955	97484	54471	45529	02516	48045	41
20	9.51991	9.97479	9.54512	10.45488	10.02521	10.48009	40
21	52027	97475	54552	45448	02525	47973	39
22	52063	97470	54593	45407	02530	47937	38
23	52099	97466	54633	45367	02534	47901	37
24	52135	97461	54673	45327	02539	47865	36
25	52171	97457	54714	45286	02543	47829	35
26	52207	97453	54754	45246	02547	47793	34
27	52242	97448	54794	45206	02552	47758	33
28	52278	97444	54835	45165	02556	47722	32
29	52314	97439	54875	45125	02561	47686	31
30	9.52350	9.97435	9.54915	10.45085	10.02565	10.47650	30
31	52385	97430	54955	45045	02570	47615	29
32	52421	97426	54995	45005	02574	47579	28
33	52456	97421	55035	44965	02579	47544	27
34	52492	97417	55075	44925	02583	47508	26
35	52527	97412	55115	44885	02588	47473	25
36	52563	97408	55155	44845	02592	47437	24
37	52598	97403	55195	44805	02597	47402	23
38	52634	97399	55235	44765	02601	47366	22
39	52669	97394	55275	44725	02606	47331	21
40	9.52705	9.97390	9.55315	10.44685	10.02610	10.47295	20
41	52740	97385	55355	44645	02615	47260	19
42	52775	97381	55395	44605	02619	47225	18
43	52811	97376	55434	44566	02624	47189	17
44	52846	97372	55474	44526	02628	47154	16
45	52881	97367	55514	44486	02633	47119	15
46	52916	97363	55554	44446	02637	47084	14
47	52951	97358	55593	44407	02642	47049	13
48	52986	97353	55633	44367	02647	47014	12
49	53021	97349	55673	44327	02651	46979	11
50	9.53056	9.97344	9.55712	10.44288	10.02656	10.46944	10
51	53092	97340	55752	44248	02660	46908	9
52	53126	97335	55791	44209	02665	46874	8
53	53161	97331	55831	44169	02669	46839	7
54	53196	97326	55870	44130	02674	46804	6
55	53231	97322	55910	44090	02678	46769	5
56	53266	97317	55949	44051	02683	46734	4
57	53301	97312	55989	44011	02688	46699	3
58	53336	97308	56028	43972	02692	46664	2
59	53370	97303	56067	43933	02697	46630	1
60	53405	97299	56107	43893	02701	46595	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

70 Degrees

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9 53405	9.97299	9.56107	10.43893	10.02701	10.46595	60
1	53440	97294	56146	43854	02706	46560	59
2	53475	97289	56185	43815	02711	46525	58
3	53509	97285	56224	43776	02715	46491	57
4	53544	97280	56264	43736	02720	46456	56
5	53578	97276	56303	43697	02724	46422	55
6	53613	97271	56342	43658	02729	46387	54
7	53647	97266	56381	43619	02734	46353	53
8	53682	97262	56420	43580	02738	46318	52
9	53716	97257	56459	43541	02743	46284	51
10	9.53751	9.97252	9.56498	10.43502	10.02748	10.46249	50
11	53785	97248	56537	43463	02752	46215	49
12	53819	97243	56576	43424	02757	46181	48
13	53854	97238	56615	43385	02762	46146	47
14	53888	97234	56654	43346	02766	46112	46
15	53922	97229	56693	43307	02771	46078	45
16	53957	97224	56732	43268	02776	46043	44
17	53991	97220	56771	43229	02780	46009	43
18	54025	97215	56810	43190	02785	45975	42
19	54059	97210	56849	43151	02790	45941	41
20	9.54093	9.97206	9.56887	10.43113	10.02794	10.45907	40
21	54127	97201	56926	43074	02799	45873	39
22	54161	97196	56965	43035	02804	45839	38
23	54195	97192	57004	42996	02808	45805	37
24	54229	97187	57042	42958	02813	45771	36
25	54263	97182	57081	42919	02818	45737	35
26	54297	97178	57120	42880	02822	45703	34
27	54331	97173	57158	42842	02827	45669	33
28	54365	97168	57197	42803	02832	45635	32
29	54399	97163	57235	42765	02837	45601	31
30	9.54433	9.97159	9.57274	10.42726	10.02841	10.45567	30
31	54466	97154	57312	42688	02846	45534	29
32	54500	97149	57351	42649	02851	45500	28
33	54534	97145	57389	42611	02855	45466	27
34	54567	97140	57428	42572	02860	45433	26
35	54601	97135	57466	42534	02865	45399	25
36	54635	97130	57504	42496	02870	45365	24
37	54668	97126	57543	42457	02874	45332	23
38	54702	97121	57581	42419	02879	45298	22
39	54735	97116	57619	42381	02884	45265	21
40	9.54769	9.97111	9.57658	10.42342	10.02889	10.45231	20
41	54802	97107	57696	42304	02893	45198	19
42	54836	97102	57734	42266	02898	45164	18
43	54869	97097	57772	42228	02903	45131	17
44	54903	97092	57810	42190	02908	45097	16
45	54936	97087	57849	42151	02913	45064	15
46	54969	97083	57887	42113	02917	45031	14
47	55003	97078	57925	42075	02922	44997	13
48	55036	97073	57963	42037	02927	44964	12
49	55069	97068	58001	41999	02932	44931	11
50	9.55102	9.97063	9.58039	10.41961	10.02937	10.44898	10
51	55136	97059	58077	41923	02941	44864	9
52	55169	97054	58115	41885	02946	44831	8
53	55202	97049	58153	41847	02951	44798	7
54	55235	97044	58191	41809	02956	44765	6
55	55268	97039	58229	41771	02961	44732	5
56	55301	97035	58267	41733	02965	44699	4
57	55334	97030	58304	41696	02970	44666	3
58	55367	97025	58342	41658	02975	44633	2
59	55400	97020	58380	41620	02980	44600	1
60	55433	97015	58418	41582	02985	44567	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

69 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.55433	9.97015	9.58418	10.41582	10.02985	10.44567	60
1	55466	97010	58455	41545	02990	44534	59
2	55499	97005	58493	41507	02995	44501	58
3	55532	97001	58531	41469	02999	44468	57
4	55564	96996	58569	41431	03004	44436	56
5	55597	96991	58606	41394	03009	44403	55
6	55630	96986	58644	41356	03014	44370	54
7	55663	96981	58681	41319	03019	44337	53
8	55695	96976	58719	41281	03024	44305	52
9	55728	96971	58757	41243	03029	44272	51
10	9.55761	9.96966	9.58794	10.41206	10.03034	10.44239	50
11	55793	96962	58832	41168	03038	44207	49
12	55826	96957	58869	41131	03043	44174	48
13	55858	96952	58907	41093	03048	44142	47
14	55891	96947	58944	41056	03053	44109	46
15	55923	96942	58981	41019	03058	44077	45
16	55956	96937	59019	40981	03063	44044	44
17	55988	96932	59056	40944	03068	44012	43
18	56021	96927	59094	40906	03073	43979	42
19	56053	96922	59131	40869	03078	43947	41
20	9.56085	9.96917	9.59168	10.40832	10.03083	10.43915	40
21	56118	96912	59205	40795	03088	43882	39
22	56150	96907	59243	40757	03093	43850	38
23	56182	96903	59280	40720	03097	43818	37
24	56215	96898	59317	40683	03102	43785	36
25	56247	96893	59354	40646	03107	43753	35
26	56279	96888	59391	40609	03112	43721	34
27	56311	96883	59429	40571	03117	43689	33
28	56343	96878	59466	40534	03122	43657	32
29	56375	96873	59503	40497	03127	43625	31
30	9.56408	9.96868	9.59540	10.40460	10.03132	10.43592	30
31	56440	96863	59577	40423	03137	43560	29
32	56472	96858	59614	40386	03142	43528	28
33	56504	96853	59651	40349	03147	43496	27
34	56536	96848	59688	40312	03152	43464	26
35	56568	96843	59725	40275	03157	43432	25
36	56599	96838	59762	40238	03162	43401	24
37	56631	96833	59799	40201	03167	43369	23
38	56663	96828	59835	40165	03172	43337	22
39	56695	96823	59872	40128	03177	43305	21
40	9.56727	9.96818	9.59909	10.40091	10.03182	10.43273	20
41	56759	96813	59946	40054	03187	43241	19
42	56790	96808	59983	40017	03192	43210	18
43	56822	96803	60019	39981	03197	43178	17
44	56854	96798	60056	39944	03202	43146	16
45	56886	96793	60093	39907	03207	43114	15
46	56917	96788	60130	39870	03212	43083	14
47	56949	96783	60166	39834	03217	43051	13
48	56980	96778	60203	39797	03222	43020	12
49	57012	96772	60240	39760	03228	42988	11
50	9.57044	9.96767	9.60276	10.39724	10 03233	10.42956	10
51	57075	96762	60313	39687	03238	42925	9
52	57107	96757	60349	39651	03243	42893	8
53	57138	96752	60386	39614	03248	42862	7
54	57169	96747	60422	39578	03253	42831	6
55	57201	96742	60459	39541	03258	42799	5
56	57232	96737	60495	39505	03263	42768	4
57	57264	96732	60532	39468	03268	42736	3
58	57295	96727	60568	39432	03273	42705	2
59	57326	96722	60605	39395	03278	42674	1
60	57358	96717	60641	39359	03283	42642	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.57358	9.96717	9.60641	10.39359	10.03283	10.42642	60
1	57389	96711	60677	39323	03289	42611	59
2	57420	96706	60714	39286	03294	42580	58
3	57451	96701	60750	39250	03299	42549	57
4	57482	96696	60786	39214	03304	42518	56
5	57514	96691	60823	39177	03309	42486	55
6	57545	96686	60859	39141	03314	42455	54
7	57576	96681	60895	39105	03319	42424	53
8	57607	96676	60931	39069	03324	42393	52
9.	57638	96670	60967	39033	03330	42362	51
10	9.57669	9.96665	9.61004	10.38996	10.03335	10.42331	50
11	57700	96660	61040	38960	03340	42300	49
12	57731	96655	61076	38924	03345	42269	48
13	57762	96650	61112	38888	03350	42238	47
14	57793	96645	61148	38852	03355	42207	46
15	57824	96640	61184	38816	03360	42176	45
16	57855	96634	61220	38780	03366	42145	44
17	57885	96629	61256	38744	03371	42115	43
18	57916	96624	61292	38708	03376	42084	42
19	57947	96619	61328	38672	03381	42053	41
20	9.57978	9.96614	9.61364	10.38636	10.03386	10.42022	40
21	58008	96608	61400	38600	03392	41992	39
22	58039	96603	61436	38564	03397	41961	38
23	58070	96598	61472	38528	03402	41930	37
24	58101	96593	61508	38492	03407	41899	36
25	58131	96588	61544	38456	03412	41869	35
26	58162	96582	61579	38421	03418	41838	34
27	58192	96577	61615	38385	03423	41808	33
28	58223	96572	61651	38349	03428	41777	32
29	58253	96567	61687	38313	03433	41747	31
30	9.58284	9.96562	9.61722	10.38278	10.03438	10.41716	30
31	58314	96556	61758	38242	03444	41686	29
32	58345	96551	61794	38206	03449	41655	28
33	58375	96546	61830	38170	03454	41625	27
34	58406	96541	61865	38135	03459	41594	26
35	58436	96535	61901	38099	03465	41564	25
36	58467	96530	61936	38064	03470	41533	24
37	58497	96525	61972	38028	03475	41503	23
38	58527	96520	62008	37992	03480	41473	22
39	58557	96514	62043	37957	03486	41443	21
40	9.58588	9.96509	9.62079	10.37921	10.03491	10.41412	20
41	58618	96504	62114	37886	03496	41382	19
42	58648	96498	62150	37850	03502	41352	18
43	58678	96493	62185	37815	03507	41322	17
44	58709	96488	62221	37779	03512	41291	16
45	58739	96483	62256	37744	03517	41261	15
46	58769	96477	62292	37708	03523	41231	14
47	58799	96472	62327	37673	03528	41201	13
48	58829	96467	62362	37638	03533	41171	12
49	58859	96461	62398	37602	03539	41141	11
50	9.58889	9.96456	9.62433	10.37567	10.03544	10.41111	10
51	58919	96451	62468	37532	03549	41081	9
52	58949	96445	62504	37496	03555	41051	8
53	58979	96440	62539	37461	03560	41021	7
54	59009	96435	62574	37426	03565	40991	6
55	59039	96429	62609	37391	03571	40961	5
56	59069	96424	62645	37355	03576	40931	4
57	59098	96419	62680	37320	03581	40902	3
58	59128	96413	62715	37285	03587	40872	2
59	59158	96408	62750	37250	03592	40842	1
60	59188	96403	62785	37215	03597	40812	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

67 Degrees.

Artificial Sines, Tang. and Sec. 23 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.59188	9.96403	9.62785	10.37215	10.03597	10.40812	60
1	59218	96397	62820	37180	03603	40782	59
2	59247	96392	62855	37145	03608	40753	58
3	59277	96387	62890	37110	03613	40723	57
4	59307	96381	62926	37074	03619	40693	56
5	59336	96376	62961	37039	03624	40664	55
6	59366	96370	62996	37004	03630	40634	54
7	59396	96365	63031	36969	03635	40604	53
8	59425	96360	63066	36934	03640	40575	52
9	59455	96354	63101	36899	03646	40545	51
10	9.59484	9.96349	9.63135	10.36865	10.03651	10.40516	50
11	59514	96343	63170	36830	03657	40486	49
12	59543	96338	63205	36795	03662	40457	48
13	59573	96333	63240	36760	03667	40427	47
14	59602	96327	63275	36725	03673	40398	46
15	59632	96322	63310	36690	03678	40368	45
16	59661	96316	63345	36655	03684	40339	44
17	59690	96311	63379	36621	03689	40310	43
18	59720	96305	63414	36586	03695	40280	42
19	59749	96300	63449	36551	03700	40251	41
20	9.59778	9.96294	9.63484	10.36516	10.03706	10.40222	40
21	59808	96289	63519	36481	03711	40192	39
22	59837	96284	63553	36447	03716	40163	38
23	59866	96278	63588	36412	03722	40134	37
24	59895	96273	63623	36377	03727	40105	36
25	59924	96267	63657	36343	03733	40076	35
26	59954	96262	63692	36308	03738	40046	34
27	59983	96256	63726	36274	03744	40017	33
28	60012	96251	63761	36239	03749	39988	32
29	60041	96245	63796	36204	03755	39959	31
30	9.60070	9.96240	9.63830	10.36170	10.03760	10.39930	30
31	60099	96234	63865	36135	03766	39901	29
32	60128	96229	63899	36101	03771	39872	28
33	60157	96223	63934	36066	03777	39843	27
34	60186	96218	63968	36032	03782	39814	26
35	60215	96212	64003	35997	03788	39785	25
36	60244	96207	64037	35963	03793	39756	24
37	60273	96201	64072	35928	03799	39727	23
38	60302	96196	64106	35894	03804	39698	22
39	60331	96190	64140	35860	03810	39669	21
40	9.60359	9.96185	9.64175	10.35825	10.03815	10.39641	20
41	60388	96179	64209	35791	03821	39612	19
42	60417	96174	64243	35757	03826	39583	18
43	60446	96168	64278	35722	03832	39554	17
44	60474	96162	64312	35688	03838	39526	16
45	60503	96157	64346	35654	03843	39497	15
46	60532	96151	64381	35619	03849	39468	14
47	60561	96146	64415	35585	03854	39439	13
48	60589	96140	64449	35551	03860	39411	12
49	60618	96135	64483	35517	03865	39382	11
50	9.60646	9.96129	9.64517	10.35483	10.03871	10.39354	10
51	60675	96123	64552	35448	03877	39325	9
52	60704	96118	64586	35414	03882	39296	8
53	60732	96112	64620	35380	03888	39268	7
54	60761	96107	64654	35346	03893	39239	6
55	60789	96101	64688	35312	03899	39211	5
56	60818	96095	64722	35278	03905	39182	4
57	60846	96090	64756	35244	03910	39154	3
58	60875	96084	64790	35210	03916	39125	2
59	60903	96079	64824	35176	03921	39097	1
60	60931	96073	64858	35142	03927	39069	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

66 Degrees.

Artificial Sines, Tang. and Sec. 24 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.60931	9.96073	9.64858	10.35142	10.03927	10.39069	60
1	60960	96067	64892	35108	03933	39040	59
2	60988	96062	64926	35074	03938	39012	58
3	61016	96056	64960	35040	03944	38984	57
4	61045	96050	64994	35006	03950	38955	56
5	61073	96045	65028	34972	03955	38927	55
6	61101	96039	65062	34938	03961	38899	54
7	61129	96034	65096	34904	03966	38871	53
8	61158	96028	65130	34870	03972	38842	52
9	61186	96022	65164	34836	03978	38814	51
10	9.61214	9.96017	9.65197	10.34803	10.03983	10.38786	50
11	61242	96011	65231	34769	03989	38758	49
12	61270	96005	65265	34735	03995	38730	48
13	61298	96000	65299	34701	04000	38702	47
14	61326	95994	65333	34667	04006	38674	46
15	61354	95988	65366	34634	04012	38646	45
16	61382	95982	65400	34600	04018	38618	44
17	61411	95977	65434	34566	04023	38589	43
18	61438	95971	65467	34533	04029	38562	42
19	61466	95965	65501	34499	04035	38534	41
20	9.61494	9.95960	9.65535	10.34465	10.04040	10.38506	40
21	61522	95954	65568	34432	04046	38478	39
22	61550	95948	65602	34398	04052	38450	38
23	61578	95942	65636	34364	04058	38422	37
24	61606	95937	65669	34331	04063	38394	36
25	61634	95931	65703	34297	04069	38366	35
26	61662	95925	65736	34264	04075	38338	34
27	61689	95920	65770	34230	04080	38311	33
28	61717	95914	65803	34197	04086	38283	32
29	61745	95908	65837	34163	04092	38255	31
30	9.61773	9.95902	9.65870	10.34130	10.04098	10.38227	30
31	61800	95897	65904	34096	04103	38200	29
32	61828	95891	65937	34063	04109	38172	28
33	61856	95885	65971	34029	04115	38144	27
34	61883	95879	66004	33996	04121	38117	26
35	61911	95873	66038	33962	04127	38089	25
36	61939	95868	66071	33929	04132	38061	24
37	61966	95862	66104	33896	04138	38034	23
38	61994	95856	66138	33862	04144	38006	22
39	62021	95850	66171	33829	04150	37979	21
40	9.62049	9.95844	9.66204	10.33796	10.04156	10.37951	20
41	62076	95839	66238	33762	04161	37924	19
42	62104	95833	66271	33729	04167	37896	18
43	62131	95827	66304	33696	04173	37869	17
44	62159	95821	66337	33663	04179	37841	16
45	62186	95815	66371	33629	04185	37814	15
46	62214	95810	66404	33596	04190	37786	14
47	62241	95804	66437	33563	04196	37759	13
48	62268	95798	66470	33530	04202	37732	12
49	62296	95792	66503	33497	04208	37704	11
50	9.62323	9.95786	9.66537	10.33463	10.04214	10.37677	10
51	62350	95780	66570	33430	04220	37650	9
52	62377	95775	66603	33397	04225	37623	8
53	62405	95769	66636	33364	04231	37595	7
54	62432	95763	66669	33331	04237	37568	6
55	62459	95757	66702	33298	04243	37541	5
56	62486	95751	66735	33265	04249	37514	4
57	62513	95745	66768	33232	04255	37487	3
58	62541	95739	66801	33199	04261	37459	2
59	62568	95733	66834	33166	04267	37432	1
60	62595	95728	66867	33133	04272	37405	0
	o-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

65 Degrees.

Artificial Sines, Tang. and Sec. 25 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.62595	9.95728	9.66867	10.33133	10.04272	10.37405	60
1	62622	95722	66900	33100	04278	37378	59
2	62649	95716	66933	33067	04284	37351	58
3	62676	95710	66966	33034	04290	37324	57
4	62703	95704	66999	33001	04296	37297	56
5	62730	95698	67032	32968	04302	37270	55
6	62757	95692	67065	32935	04308	37243	54
7	62784	95686	67098	32902	04314	37216	53
8	62811	95680	67131	32869	04320	37189	52
9	62838	95674	67163	32837	04326	37162	51
10	9.62865	9.95668	9.67196	10.32804	10.04332	10.37135	50
11	62892	95663	67229	32771	04337	37108	49
12	62918	95657	67262	32738	04343	37082	48
13	62945	95651	67295	32705	04349	37055	47
14	62972	95645	67327	32673	04355	37028	46
15	62999	95639	67360	32640	04361	37001	45
16	63026	95633	67393	32607	04367	36974	44
17	63052	95627	67426	32574	04373	36948	43
18	63079	95621	67458	32542	04379	36921	42
19	63106	95615	67491	32509	04385	36894	41
20	9.63133	9.95609	9.67524	10.32476	10.04391	10.36867	40
21	63159	95603	67556	32444	04397	36841	39
22	63186	95597	67589	32411	04403	36814	38
23	63213	95591	67622	32378	04409	36787	37
24	63239	95585	67654	32346	04415	36761	36
25	63266	95579	67687	32313	04421	36734	35
26	63292	95573	67719	32281	04427	36708	34
27	63319	95567	67752	32248	04433	36681	33
28	63345	95561	67785	32215	04439	36655	32
29	63372	95555	67817	32183	04445	36628	31
30	9.63398	9.95549	9.67850	10.32150	10.04451	10.36602	30
31	63425	95543	67882	32118	04457	36575	29
32	63451	95537	67915	32085	04463	36549	28
33	63478	95531	67947	32053	04469	36522	27
34	63504	95525	67980	32020	04475	36496	26
35	63531	95519	68012	31988	04481	36469	25
36	63557	95513	68044	31956	04487	36443	24
37	63583	95507	68077	31923	04493	36417	23
38	63610	95500	68109	31891	04500	36390	22
39	63636	95494	68142	31858	04506	36364	21
40	9.63662	9.95488	9.68174	10.31826	10.04512	10.36338	20
41	63689	95482	68206	31794	04518	36311	19
42	63715	95476	68239	31761	04524	36285	18
43	63741	95470	68271	31729	04530	36259	17
44	63767	95464	68303	31697	04536	36233	16
45	63794	95458	68336	31664	04542	36206	15
46	63820	95452	68368	31632	04548	36180	14
47	63846	95446	68400	31600	04554	36154	13
48	63872	95440	68432	31568	04560	36128	12
49	63898	95434	68465	31535	04566	36102	11
50	9.63924	9.95427	9.68497	10.31503	10.04573	10.36076	10
51	63950	95421	68529	31471	04579	36050	9
52	63976	95415	68561	31439	04585	36024	8
53	64002	95409	68593	31407	04591	35998	7
54	64028	95403	68626	31374	04597	35972	6
55	64054	95397	68658	31342	04603	35946	5
56	64080	95391	68690	31310	04609	35920	4
57	64106	95384	68722	31278	04616	35894	
58	64132	95378	68754	31246	04622	35868	2
59	64158	95372	68786	31214	04628	35842	1
60	64184	95366	68818	31182	04634	35816	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.64134	9.95366	9.68818	10.31182	10.04634	10.35816	60
1	64210	95360	68850	31150	04640	35790	59
2	64236	95354	68882	31118	04646	35764	58
3	64262	95348	68914	31086	04652	35738	57
4	64288	95341	68946	31054	04659	35712	56
5	64313	95335	68978	31022	04665	35687	55
6	64339	95329	69010	30990	04671	35661	54
7	64365	95323	69042	30958	04677	35635	53
8	64391	95317	69074	30926	04683	35609	52
9	64417	95310	69106	30894	04690	35583	51
10	9.64442	9.95304	9.69138	10.30862	10.04696	10.35558	50
11	64468	95298	69170	30830	04702	35532	49
12	64494	95292	69202	30798	04708	35506	48
13	64519	95286	69234	30766	04714	35481	47
14	64545	95279	69266	30734	04721	35455	46
15	64571	95273	69298	30702	04727	35429	45
16	64596	95267	69329	30671	04733	35404	44
17	64622	95261	69361	30639	04739	35378	43
18	64647	95254	69393	30607	04746	35353	42
19	64673	95248	69425	30575	04752	35327	41
20	9.64698	9.95242	9.69457	10.30543	10.04758	10.35302	40
21	64724	95236	69488	30512	04764	35276	39
22	64749	95229	69520	30480	04771	35251	38
23	64775	95223	69552	30448	04777	35225	37
24	64800	95217	69584	30416	04783	35200	36
25	64826	95211	69615	30385	04789	35174	35
26	64851	95204	69647	30353	04796	35149	34
27	64877	95198	69679	30321	04802	35123	33
28	64902	95192	69710	30290	04808	35098	32
29	64927	95185	69742	30258	04815	35073	31
30	9.64953	9.95179	9.69774	10.30226	10.04821	10.35047	30
31	64978	95173	69805	30195	04827	35022	29
32	65003	95167	69837	30163	04833	34997	28
33	65029	95160	69868	30132	04840	34971	27
34	65054	95154	69900	30100	04846	34946	26
35	65079	95148	69932	30068	04852	34921	25
36	65104	95141	69963	30037	04859	34896	24
37	65130	95135	69995	30005	04865	34870	23
38	65155	95129	70026	29974	04871	34845	22
39	65180	95122	70058	29942	04878	34820	21
40	9.65205	9.95116	9.70089	10.29911	10.04884	10.34795	20
41	65230	95110	70121	29879	04890	34770	19
42	65255	95103	70152	29848	04897	34745	18
43	65281	95097	70184	29816	04903	34719	17
44	65306	95090	70215	29785	04910	34694	16
45	65331	95084	70247	29753	04916	34669	15
46	65356	95078	70278	29722	04922	34644	14
47	65381	95071	70309	29691	04929	34619	13
48	65406	95065	70341	29659	04935	34594	12
49	65431	95059	70372	29628	04941	34569	11
50	9.65456	9.95052	9.70404	10.29596	10.04948	10.34544	10
51	65481	95046	70435	29565	04954	34519	9
52	65506	95039	70466	29534	04961	34494	8
53	65531	95033	70498	29502	04967	34469	7
54	65556	95027	70529	29471	04973	34444	6
55	65580	95020	70560	29440	04980	34420	5
56	65605	95014	70592	29408	04986	34395	4
57	65630	95007	70623	29377	04993	34370	3
58	65655	95001	70654	29346	04999	34345	2
59	65680	94995	70685	29315	05005	34320	1
60	65705	94988	70717	29283	05012	34295	0
M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

63 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.65705	9.94988	9.70717	10.29283	10.05012	10.34295	60
1	65729	94982	70748	29252	05018	34271	59
2	65754	94975	70779	29221	05025	34246	58
3	65779	94969	70810	29190	05031	34221	57
4	65804	94962	70841	29159	05038	34196	56
5	65828	94956	70873	29127	05044	34172	55
6	65853	94949	70904	29096	05051	34147	54
7	65878	94943	70935	29065	05057	34122	53
8	65902	94936	70966	29034	05064	34098	52
9	65927	94930	70997	29003	05070	34073	51
10	9.65952	9.94923	9.71028	10.28972	10.05077	10.34048	50
11	65976	94917	71059	28941	05083	34024	49
12	66001	94911	71090	28910	05089	33999	48
13	66025	94904	71121	28879	05096	33975	47
14	66050	94898	71153	28847	05102	33950	46
15	66075	94891	71184	28816	05109	33925	45
16	66099	94885	71215	28785	05115	33901	44
17	66124	94878	71246	28754	05122	33876	43
18	66148	94871	71277	28723	05129	33852	42
19	66173	94865	71308	28692	05135	33827	41
20	9.66197	9.94858	9.71339	10.28661	10.05142	10.33803	40
21	66221	94852	71370	28630	05148	33779	39
22	66246	94845	71401	28599	05155	33754	38
23	66270	94839	71431	28569	05161	33730	37
24	66295	94832	71462	28538	05168	33705	36
25	66319	94826	71493	28507	05174	33681	35
26	66343	94819	71524	28476	05181	33657	34
27	66368	94813	71555	28445	05187	33632	33
28	66392	94806	71586	28414	05194	33608	32
29	66416	94799	71617	28383	05201	33584	31
30	9.66441	9.94793	9.71648	10.28352	10.05207	10.33559	30
31	66465	94786	71679	28321	05214	33535	29
32	66489	94780	71709	28291	05220	33511	28
33	66513	94773	71740	28260	05227	33487	27
34	66537	94767	71771	28229	05233	33463	26
35	66562	94760	71802	28198	05240	33438	25
36	66586	94753	71833	28167	05247	33414	24
37	66610	94747	71863	28137	05253	33390	23
38	66634	94740	71894	28106	05260	33366	22
39	66658	94734	71925	28075	05266	33342	21
40	9.66682	9.94727	9.71955	10.28045	10.05273	10.33318	20
41	66706	94720	71986	28014	05280	33294	19
42	66731	94714	72017	27983	05286	33269	18
43	66755	94707	72048	27952	05293	33245	17
44	66779	94700	72078	27922	05300	33221	16
45	66803	94694	72109	27891	05306	33197	15
46	66827	94687	72140	27860	05313	33173	14
47	66851	94680	72170	27830	05320	33149	13
48	66875	94674	72201	27799	05326	33125	12
49	66899	94667	72231	27769	05333	33101	11
50	9.66922	9.94660	9.72262	10.27738	10.05340	10.33078	10
51	66946	94654	72293	27707	05346	33054	9
52	66970	94647	72323	27677	05353	33030	8
53	66994	94640	72354	27646	05360	33006	7
54	67018	94634	72384	27616	05366	32982	6
55	67042	94627	72415	27585	05373	32958	5
56	67066	94620	72445	27555	05380	32934	4
57	67090	94614	72476	27524	05386	32910	3
58	67113	94607	72506	27494	05393	32887	2
59	67137	94600	72537	27463	05400	32863	1
60	67161	94593	72567	27433	05407	32839	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.67161	9.94593	9.72567	10.27433	10.05407	10.32839	60
1	67185	94587	72598	27402	05413	32815	59
2	67208	94580	72628	27372	05420	32792	58
3	67232	94573	72659	27341	05427	32768	57
4	67256	94567	72689	27311	05433	32744	56
5	67280	94560	72720	27280	05440	32720	55
6	67303	94553	72750	27250	05447	32697	54
7	67327	94546	72780	27220	05454	32673	53
8	67350	94540	72811	27189	05460	32650	52
9	67374	94533	72841	27159	05467	32626	51
10	9.67398	9.94526	9.72872	10.27128	10.05474	10.32602	50
11	67421	94519	72902	27098	05481	32579	49
12	67445	94513	72932	27068	05487	32555	48
13	67468	94506	72963	27037	05494	32532	47
14	67492	94499	72993	27007	05501	32508	46
15	67515	94492	73023	26977	05508	32485	45
16	67539	94485	73054	26946	05515	32461	44
17	67562	94479	73084	26916	05521	32438	43
18	67586	94472	73114	26886	05528	32414	42
19	67609	94465	73144	26856	05535	32391	41
20	9.67633	9.94458	9.73175	10.26825	10.05542	10.32367	40
21	67656	94451	73205	26795	05549	32344	39
22	67680	94445	73235	26765	05555	32320	38
23	67703	94438	73265	26735	05562	32297	37
24	67726	94431	73295	26705	05569	32274	36
25	67750	94424	73326	26674	05576	32250	35
26	67773	94417	73356	26644	05583	32227	34
27	67796	94410	73386	26614	05590	32204	33
28	67820	94404	73416	26584	05596	32180	32
29	67843	94397	73446	26554	05603	32157	31
30	9.67866	9.94390	9.73476	10.26524	10.05610	10.32134	30
31	67890	94383	73507	26493	05617	32110	29
32	67913	94376	73537	26463	05624	32087	28
33	67936	94369	73567	26433	05631	32064	27
34	67959	94362	73597	26403	05638	32041	26
35	67982	94355	73627	26373	05645	32018	25
36	68006	94349	73657	26343	05651	31994	24
37	68029	94342	73687	26313	05658	31971	23
38	68052	94335	73717	26283	05665	31948	22
39	68075	94328	73747	26253	05672	31925	21
40	9.68098	9.94321	9.73777	10.26223	10.05679	10.31902	20
41	68121	94314	73807	26193	05686	31879	19
42	68144	94307	73837	26163	05693	31856	18
43	68167	94300	73867	26133	05700	31833	17
44	68190	94293	73897	26103	05707	31810	16
45	68213	94286	73927	26073	05714	31787	15
46	68237	94279	73957	26043	05721	31763	14
47	68260	94273	73987	26013	05727	31740	13
48	68283	94266	74017	25983	05734	31717	12
49	68305	94259	74047	25953	05741	31695	11
50	9.68328	9.94252	9.74077	10.25923	10.05748	10.31672	10
51	68351	94245	74107	25893	05755	31649	9
52	68374	94238	74137	25863	05762	31626	8
53	68397	94231	74166	25834	05769	31603	7
54	68420	94224	74196	25804	05776	31580	6
55	68443	94217	74226	25774	05783	31557	5
56	68466	94210	74256	25744	05790	31534	4
57	68489	94203	74286	25714	05797	31511	3
58	68512	94196	74316	25684	05804	31488	2
59	68534	94189	74345	25655	05811	31466	1
60	68557	94182	74375	25625	05818	31443	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

61 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.68557	9.94182	9.74375	10.25625	10.05818	10.31443	60
1	68580	94175	74405	25595	05825	31420	59
2	68603	94168	74435	25565	05832	31397	58
3	68625	94161	74465	25535	05839	31375	57
4	68648	94154	74494	25506	05846	31352	56
5	68671	94147	74524	25476	05853	31329	55
6	68694	94140	74554	25446	05860	31306	54
7	68716	94133	74583	25417	05867	31284	53
8	68739	94126	74613	25387	05874	31261	52
9	68762	94119	74643	25357	05881	31238	51
10	9.68784	9.94112	9.74673	10.25327	10.05888	10.31216	50
11	68807	94105	74702	25298	05895	31193	49
12	68829	94098	74732	25268	05902	31171	48
13	68852	94090	74762	25238	05910	31148	47
14	68875	94083	74791	25209	05917	31125	46
15	68897	94076	74821	25179	05924	31103	45
16	68920	94069	74851	25149	05931	31080	44
17	68942	94062	74880	25120	05938	31058	43
18	68965	94055	74910	25090	05945	31035	42
19	68987	94048	74939	25061	05952	31013	41
20	9.69010	9.94041	9.74969	10.25031	10.05959	10.30990	40
21	69032	94034	74998	25002	05966	30968	39
22	69055	94027	75028	24972	05973	30945	38
23	69077	94020	75058	24942	05980	30923	37
24	69100	94012	75087	24913	05988	30900	36
25	69122	94005	75117	24883	05995	30878	35
26	69144	93998	75146	24854	06002	30856	34
27	69167	93991	75176	24824	06009	30833	33
28	69189	93984	75205	24795	06016	30811	32
29	69212	93977	75235	24765	06023	30788	31
30	9.69234	9.93970	9.75264	10.24736	10.06030	10.30766	30
31	69256	93963	75294	24706	06037	30744	29
32	69279	93955	75323	24677	06045	30721	28
33	69301	93948	75353	24647	06052	30699	27
34	69323	93941	75382	24618	06059	30677	26
35	69345	93934	75411	24589	06066	30655	25
36	69368	93927	75441	24559	06073	30632	24
37	69390	93920	75470	24530	06080	30610	23
38	69412	93912	75500	24500	06088	30588	22
39	69434	93905	75529	24471	06095	30566	21
40	9.69456	9.93898	9.75558	10.24442	10.06102	10.30544	20
41	69479	93891	75588	24412	06109	30521	19
42	69501	93884	75617	24383	06116	30499	18
43	69523	93876	75647	24353	06124	30477	17
44	69545	93869	75676	24324	06131	30455	16
45	69567	93862	75705	24295	06138	30433	15
46	69589	93855	75735	24265	06145	30411	14
47	69611	93847	75764	24236	06153	30389	13
48	69633	93840	75793	24207	06160	30367	12
49	69655	93833	75822	24178	06167	30345	11
50	9.69677	9.93826	9.75852	10.24148	10.06174	10.30323	10
51	69699	93819	75881	24119	06181	30301	9
52	69721	93811	75910	24090	06189	30279	8
53	69743	93804	75939	24061	06196	30257	7
54	69765	93797	75969	24031	06203	30235	6
55	69787	93789	75998	24002	06211	30213	5
56	69809	93782	76027	23973	06218	30191	4
57	69831	93775	76056	23944	06225	30169	3
58	69853	93768	76086	23914	06232	30147	2
59	69875	93760	76115	23885	06240	30125	1
60	69897	93753	76144	23856	06247	30103	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant	M.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant
0	9.69897	9.93753	9.76144	10.23856	10.06247	10.30103
1	69919	93746	76173	23827	06254	30081
2	69941	93738	76202	23798	06262	3005
3	69963	93731	76231	23769	06269	3003
4	69984	93724	76261	23739	06276	3001
5	70006	93717	76290	23710	06283	2999
6	70028	93709	76319	23681	06291	2997
7	70050	93702	76348	23652	06298	2995
8	70072	93695	76377	23623	06305	2992
9	70093	93687	76406	23594	06313	2990
10	9.70115	9.93680	9.76435	10.23565	10.06320	10.2988
11	70137	93673	76464	23536	06327	2986
12	70159	93665	76493	23507	06335	2984
13	70180	93658	76522	23478	06342	2982
14	70202	93650	76551	23449	06350	2979
15	70224	93643	76580	23420	06357	2977
16	70245	93636	76609	23391	06364	2975
17	70267	93628	76639	23361	06372	2973
18	70288	93621	76668	23332	06379	2971
19	70310	93614	76697	23303	06386	2969
20	9.70332	9.93606	9.76725	10.23275	10.06394	10.2966
21	70353	93599	76754	23246	06401	2964
22	70375	93591	76783	23217	06409	2962
23	70396	93584	76812	23188	06416	2960
24	70418	93577	76841	23159	06423	2958
25	70439	93569	76870	23130	06431	2956
26	70461	93562	76899	23101	06438	2953
27	70482	93554	76928	23072	06446	2951
28	70504	93547	76957	23043	06453	2949
29	70525	93539	76986	23014	06461	2947
30	9.70547	9.93532	9.77015	10.22985	10.06468	10.2945
31	70568	93525	77044	22956	06475	2943
32	70590	93517	77073	22927	06483	2941
33	70611	93510	77101	22899	06490	2938
34	70633	93502	77130	22870	06498	2936
35	70654	93495	77159	22841	06505	2934
36	70675	93487	77188	22812	06513	2932
37	70697	93480	77217	22783	06520	2930
38	70718	93472	77246	22754	06528	2928
39	70739	93465	77274	22726	06535	2926
40	9.70761	9.93457	9.77303	10.22697	10.06543	10.2923
41	70782	93450	77332	22668	06550	2921
42	70803	93442	77361	22639	06558	2919
43	70824	93435	77390	22610	06565	2917
44	70846	93427	77418	22582	06573	2915
45	70867	93420	77447	22553	06580	2913
46	70888	93412	77476	22524	06588	2911
47	70909	93405	77505	22495	06595	2909
48	70931	93397	77533	22467	06603	2906
49	70952	93390	77562	22438	06610	2904
50	9.70973	9.93382	9.77591	10.22409	10.06618	10.2902
51	70994	93375	77619	22381	06625	2900
52	71015	93367	77648	22352	06633	2898
53	71036	93360	77677	22323	06640	2896
54	71058	93352	77706	22294	06648	2894
55	71079	93344	77734	22266	06656	2892
56	71100	93337	77763	22237	06663	2890
57	71121	93329	77791	22209	06671	2887
58	71142	93322	77820	22180	06678	2885
59	71163	93314	77849	22151	06686	2883
60	71184	93307	77877	22123	06693	2881
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.

59 Degrees

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.71184	9.93307	9.77877	10.22123	10.06693	10.28816	60
1	71205	93299	77906	22094	06701	28795	59
2	71226	93291	77935	22065	06709	28774	58
3	71247	93284	77963	22037	06716	28753	57
4	71268	93276	77992	22008	06724	28732	56
5	71289	93269	78020	21980	06731	28711	55
6	71310	93261	78049	21951	06739	28690	54
7	71331	93253	78077	21923	06747	28669	53
8	71352	93246	78106	21894	06754	28648	52
9	71373	93238	78135	21865	06762	28627	51
10	9.71393	9.93230	9.78163	10.21837	10.06770	10.28607	50
11	71414	93223	78192	21808	06777	28586	49
12	71435	93215	78220	21780	06785	28565	48
13	71456	93207	78249	21751	06793	28544	47
14	71477	93200	78277	21723	06800	28523	46
15	71498	93192	78306	21694	06808	28502	45
16	71519	93184	78334	21666	06816	28481	44
17	71539	93177	78363	21637	06823	28461	43
18	71560	93169	78391	21609	06831	28440	42
19	71581	93161	78419	21581	06839	28419	41
20	9.71602	9.93154	9.78448	10.21552	10.06846	10.28398	40
21	71622	93146	78476	21524	06854	28378	39
22	71643	93138	78505	21495	06862	28357	38
23	71664	93131	78533	21467	06869	28336	37
24	71685	93123	78562	21438	06877	28315	36
25	71705	93115	78590	21410	06885	28295	35
26	71726	93108	78618	21382	06892	28274	34
27	71747	93100	78647	21353	06900	28253	33
28	71767	93092	78675	21325	06908	28233	32
29	71788	93084	78704	21296	06916	28212	31
30	9.71809	9.93077	9.78732	10.21268	10.06923	10.28191	30
31	71829	93069	78760	21240	06931	28171	29
32	71850	93061	78789	21211	06939	28150	28
33	71870	93053	78817	21183	06947	28130	27
34	71891	93046	78845	21155	06954	28109	26
35	71911	93038	78874	21126	06962	28089	25
36	71932	93030	78902	21098	06970	28068	24
37	71952	93022	78930	21070	06978	28048	23
38	71973	93014	78959	21041	06986	28027	22
39	71994	93007	78987	21013	06993	28006	21
40	9.72014	9.92999	9.79015	10.20985	10.07001	10.27986	20
41	72034	92991	79043	20957	07009	27966	19
42	72055	92983	79072	20928	07017	27945	18
43	72075	92976	79100	20900	07024	27925	17
44	72096	92968	79128	20872	07032	27904	16
45	72116	92960	79156	20844	07040	27884	15
46	72137	92952	79185	20815	07048	27863	14
47	72157	92944	79213	20787	07056	27843	13
48	72177	92936	79241	20759	07064	27823	12
49	72198	92929	79269	20731	07071	27802	11
50	9.72218	9.92921	9.79297	10.20703	10.07079	10.27782	10
51	72238	92913	79326	20674	07087	27762	9
52	72259	92905	79354	20646	07095	27741	8
53	72279	92897	79382	20618	07103	27721	7
54	72299	92889	79410	20590	07111	27701	6
55	72320	92881	79438	20562	07119	27680	5
56	72340	92874	79466	20534	07126	27660	4
57	72360	92866	79495	20505	07134	27640	3
58	72381	92858	79523	20477	07142	27619	2
59	72401	92850	79551	20449	07150	27599	1
60	72421	92842	79579	20421	07158	27579	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

58 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.72421	9.92842	9.79579	10.20421	10.07158	10.27579	60
1	72441	92834	79607	20393	07166	27559	59
2	72461	92826	79635	20365	07174	27539	58
3	72482	92818	79663	20337	07182	27518	57
4	72502	92810	79691	20309	07190	27498	56
5	72522	92803	79719	20281	07197	27478	55
6	72542	92795	79747	20253	07205	27458	54
7	72562	92787	79776	20224	07213	27438	53
8	72582	92779	79804	20196	07221	27418	52
9	72602	92771	79832	20168	07229	27398	51
10	9.72622	9.92763	9.79860	10.20140	10.07237	10.27378	50
11	72643	92755	79888	20112	07245	27357	49
12	72663	92747	79916	20084	07253	27337	48
13	72683	92739	79944	20056	07261	27317	47
14	72703	92731	79972	20028	07269	27297	46
15	72723	92723	80000	20000	07277	27277	45
16	72743	92715	80028	19972	07285	27257	44
17	72763	92707	80056	19944	07293	27237	43
18	72783	92699	80084	19916	07301	27217	42
19	72803	92691	80112	19888	07309	27197	41
20	9.72823	9.92683	9.80140	10.19860	10.07317	10.27177	40
21	72843	92675	80168	19832	07325	27157	39
22	72863	92667	80195	19805	07333	27137	38
23	72883	92659	80223	19777	07341	27117	37
24	72902	92651	80251	19749	07349	27098	36
25	72922	92643	80279	19721	07357	27078	35
26	72942	92635	80307	19693	07365	27058	34
27	72962	92627	80335	19665	07373	27038	33
28	72982	92619	80363	19637	07381	27018	32
29	73002	92611	80391	19609	07389	26998	31
30	9.73022	9.92603	9.80419	10.19581	10.07397	10.26978	30
31	73041	92595	80447	19553	07405	26959	29
32	73061	92587	80474	19526	07413	26939	28
33	73081	92579	80502	19498	07421	26919	27
34	73101	92571	80530	19470	07429	26899	26
35	73121	92563	80558	19442	07437	26879	25
36	73140	92555	80586	19414	07445	26860	24
37	73160	92546	80614	19386	07454	26840	23
38	73180	92538	80642	19358	07462	26820	22
39	73200	92530	80669	19331	07470	26800	21
40	9.73219	9.92522	9.80697	10.19303	10.07478	10.26781	20
41	73239	92514	80725	19275	07486	26761	19
42	73259	92506	80753	19247	07494	26741	18
43	73278	92498	80781	19219	07502	26722	17
44	73298	92490	80808	19192	07510	26702	16
45	73318	92482	80836	19164	07518	26682	15
46	73337	92473	80864	19136	07527	26663	14
47	73357	92465	80892	19108	07535	26643	13
48	73377	92457	80919	19081	07543	26623	12
49	73396	92449	80947	19053	07551	26604	11
50	9.73416	9.92441	9.80975	10.19025	10.07559	10.26584	10
51	73435	92433	81003	18997	07567	26565	9
52	73455	92425	81030	18970	07575	26545	8
53	73474	92416	81058	18942	07584	26526	7
54	73494	92408	81086	18914	07592	26506	6
55	73513	92400	81113	18887	07600	26487	5
56	73533	92392	81141	18859	07608	26467	4
57	73552	92384	81169	18831	07616	26448	3
58	73572	92376	81196	18804	07624	26428	2
59	73591	92367	81224	18776	07633	26409	1
60	73611	92359	81252	18748	07641	26389	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

57 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.73611	9.92359	9.81252	10.18748	10.07641	10.26389	60
1	73630	92351	81279	18721	07649	26370	59
2	73650	92343	81307	18693	07657	26350	58
3	73669	92335	81335	18665	07665	26331	57
4	73689	92326	81362	18638	07674	26311	56
5	73708	92318	81390	18610	07682	26292	55
6	73727	92310	81418	18582	07690	26273	54
7	73747	92302	81445	18555	07698	26253	53
8	73766	92293	81473	18527	07707	26234	52
9	73785	92285	81500	18500	07715	26215	51
10	9.73805	9.92277	9.81528	10.18472	10.07723	10.26195	50
11	73824	92269	81556	18444	07731	26176	49
12	73843	92260	81583	18417	07740	26157	48
13	73863	92252	81611	18389	07748	26137	47
14	73882	92244	81638	18362	07756	26118	46
15	73901	92235	81666	18334	07765	26099	45
16	73921	92227	81693	18307	07773	26079	44
17	73940	92219	81721	18279	07781	26060	43
18	73959	92211	81748	18252	07789	26041	42
19	73978	92202	81776	18224	07798	26022	41
20	9.73997	9.92194	9.81803	10.18197	10.07806	10.26003	40
21	74017	92186	81831	18169	07814	25983	39
22	74036	92177	81858	18142	07823	25964	38
23	74055	92169	81886	18114	07831	25945	37
24	74074	92161	81913	18087	07839	25926	36
25	74093	92152	81941	18059	07848	25907	35
26	74113	92144	81968	18032	07856	25887	34
27	74132	92136	81996	18004	07864	25868	33
28	74151	92127	82023	17977	07873	25849	32
29	74170	92119	82051	17949	07881	25830	31
30	9.74189	9.92111	9.82078	10.17922	10.07889	10.25811	30
31	74208	92102	82106	17894	07898	25792	29
32	74227	92094	82133	17867	07906	25773	28
33	74246	92086	82161	17839	07914	25754	27
34	74265	92077	82188	17812	07923	25735	26
35	74284	92069	82215	17785	07931	25716	25
36	74303	92060	82243	17757	07940	25697	24
37	74322	92052	82270	17730	07948	25678	23
38	74341	92044	82298	17702	07956	25659	22
39	74360	92035	82325	17675	07965	25640	21
40	9.74379	9.92027	9.82352	10.17648	10.07973	10.25621	20
41	74398	92018	82380	17620	07982	25602	19
42	74417	92010	82407	17593	07990	25583	18
43	74436	92002	82435	17565	07998	25564	17
44	74455	91993	82462	17538	08007	25545	16
45	74474	91985	82489	17511	08015	25526	15
46	74493	91976	82517	17483	08024	25507	14
47	74512	91968	82544	17456	08032	25488	13
48	74531	91959	82571	17429	08041	25469	12
49	74549	91951	82599	17401	08049	25451	11
50	9.74568	9.91942	9.82626	10.17374	10.08058	10.25432	10
51	74587	91934	82653	17347	08066	25413	9
52	74606	91925	82681	17319	08075	25394	8
53	74625	91917	82708	17292	08083	25375	7
54	74644	91908	82735	17265	08092	25356	6
55	74662	91900	82762	17238	08100	25338	5
56	74681	91891	82790	17210	08109	25319	4
57	74700	91883	82817	17183	08117	25300	3
58	74719	91874	82844	17156	08126	25281	2
59	74737	91866	82871	17129	08134	25263	1
60	74756	91857	82899	17101	08143	25244	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

56 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.74756	9.91857	9.82899	10.17101	10.08143	10.25244	60
1	74775	91849	82926	17074	08151	25225	59
2	74794	91840	82953	17047	08160	25206	58
3	74812	91832	82980	17020	08168	25188	57
4	74831	91823	83008	16992	08177	25169	56
5	74850	91815	83035	16965	08185	25150	55
6	74868	91806	83062	16938	08194	25132	54
7	74887	91798	83089	16911	08202	25113	53
8	74906	91789	83117	16883	08211	25094	52
9	74924	91781	83144	16856	08219	25076	51
10	9.74943	9.91772	9.83171	10.16829	10.08228	10.25057	50
11	74961	91763	83198	16802	08237	25039	49
12	74980	91755	83225	16775	08245	25020	48
13	74999	91746	83252	16748	08254	25001	47
14	75017	91738	83280	16720	08262	24983	46
15	75036	91729	83307	16693	08271	24964	45
16	75054	91720	83334	16666	08280	24946	44
17	75073	91712	83361	16639	08288	24927	43
18	75091	91703	83388	16612	08297	24909	42
19	75110	91695	83415	16585	08305	24890	41
20	9.75128	9.91686	9.83442	10.16558	10.08314	10.24872	40
21	75147	91677	83470	16530	08323	24853	39
22	75165	91669	83497	16503	08331	24825	38
23	75184	91660	83524	16476	08340	24816	37
24	75202	91651	83551	16449	08349	24798	36
25	75221	91643	83578	16422	08357	24779	35
26	75239	91634	83605	16395	08366	24761	34
27	75258	91625	83632	16368	08375	24742	33
28	75276	91617	83659	16341	08383	24724	32
29	75294	91608	83686	16314	08392	24706	31
30	9.75313	9.91599	9.83713	10.16287	10.08401	10.24687	30
31	75331	91591	83740	16260	08409	24669	29
32	75350	91582	83768	16232	08418	24650	28
33	75368	91573	83795	16205	08427	24632	27
34	75386	91565	83822	16178	08435	24614	26
35	75405	91556	83849	16151	08444	24595	25
36	75423	91547	83876	16124	08453	24577	24
37	75441	91538	83903	16097	08462	24559	23
38	75459	91530	83930	16070	08470	24541	22
39	75478	91521	83957	16043	08479	24522	21
40	9.75496	9.91512	9.83984	10.16016	10.08488	10.24504	20
41	75514	91504	84011	15989	08496	24486	19
42	75533	91495	84038	15962	08505	24467	18
43	75551	91486	84065	15935	08514	24449	17
44	75569	91477	84092	15908	08523	24431	16
45	75587	91469	84119	15881	08531	24413	15
46	75605	91460	84146	15854	08540	24395	14
47	75624	91451	84173	15827	08549	24376	13
48	75642	91442	84200	15800	08558	24358	12
49	75660	91433	84227	15773	08567	24340	11
50	9.75678	9.91425	9.84254	10.15746	10.08575	10.24322	10
51	75696	91416	84280	15720	08584	24304	9
52	75714	91407	84307	15693	08593	24286	8
53	75733	91398	84334	15666	08602	24267	7
54	75751	91389	84361	15639	08611	24249	6
55	75769	91381	84388	15612	08619	24231	5
56	75787	91372	84415	15585	08628	24213	4
57	75805	91363	84442	15558	08637	24195	3
58	75823	91354	84469	15531	08646	24177	2
59	75841	91345	84496	15504	08655	24159	1
60	75859	91336	84523	15477	08664	24141	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

55 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.75859	9.91336	9.84523	10.15477	10.08664	10.24141	60
1	75877	91328	84550	15450	08672	24123	59
2	75895	91319	84576	15424	08681	24105	58
3	75913	91310	84603	15397	08690	24087	57
4	75931	91301	84630	15370	08699	24069	56
5	75949	91292	84657	15343	08708	24051	55
6	75967	91283	84684	15316	08717	24033	54
7	75985	91274	84711	15289	08726	24015	53
8	76003	91265	84738	15262	08734	23997	52
9	76021	91257	84764	15236	08743	23979	51
10	9.76039	9.91248	9.84791	10.15209	10.08752	10.23961	50
11	76057	91239	84818	15182	08761	23943	49
12	76075	91230	84845	15155	08770	23925	48
13	76093	91221	84872	15128	08779	23907	47
14	76111	91212	84899	15101	08788	23889	46
15	76129	91203	84925	15075	08797	23871	45
16	76146	91194	84952	15048	08806	23854	44
17	76164	91185	84979	15021	08815	23836	43
18	76182	91176	85006	14994	08824	23818	42
19	76200	91167	85033	14967	08833	23800	41
20	9.76218	9.91158	9.85059	10.14941	10.08842	10.23782	40
21	76236	91149	85086	14914	08851	23764	39
22	76253	91141	85113	14887	08859	23747	38
23	76271	91132	85140	14860	08868	23729	37
24	76289	91123	85166	14834	08877	23711	36
25	76307	91114	85193	14807	08886	23693	35
26	76324	91105	85220	14780	08895	23676	34
27	76342	91096	85247	14753	08904	23658	33
28	76360	91087	85273	14727	08913	23640	32
29	76378	91078	85300	14700	08922	23622	31
30	9.76395	9.91069	9.85327	10.14673	10.08931	10.23605	30
31	76413	91060	85354	14646	08940	23587	29
32	76431	91051	85380	14620	08949	23569	28
33	76448	91042	85407	14593	08958	23552	27
34	76466	91033	85434	14566	08967	23534	26
35	76484	91023	85460	14540	08977	23516	25
36	76501	91014	85487	14513	08986	23499	24
37	76519	91005	85514	14486	08995	23481	23
38	76537	90996	85540	14460	09004	23463	22
39	76554	90987	85567	14433	09013	23446	21
40	9.76572	9.90978	9.85594	10.14406	10.09022	10.23428	20
41	76590	90969	85620	14380	09031	23410	19
42	76607	90960	85647	14353	09040	23393	18
43	76625	90951	85674	14326	09049	23375	17
44	76642	90942	85700	14300	09058	23358	16
45	76660	90933	85727	14273	09067	23340	15
46	76677	90924	85754	14246	09076	23323	14
47	76695	90915	85780	14220	09085	23305	13
48	76712	90906	85807	14193	09094	23288	12
49	76730	90896	85834	14166	09104	23270	11
50	9.76747	9.90887	9.85860	10.14140	10.09113	10.23253	10
51	76765	90878	85887	14113	09122	23235	9
52	76782	90869	85913	14087	09131	23218	8
53	76800	90860	85940	14060	09140	23200	7
54	76817	90851	85967	14033	09149	23183	6
55	76835	90842	85993	14007	09158	23165	5
56	76852	90832	86020	13980	09168	23148	4
57	76870	90823	86046	13954	09177	23130	3
58	76887	90814	86073	13927	09186	23113	2
59	76904	90805	86100	13900	09195	23096	1
60	76922	90796	86126	13874	09204	23078	0
M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

54 Degrees.

Artificial Sines, Tang. and Sec. 36 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.76922	9.90796	9.86126	10.13874	10.09204	10.23078	60
1	76939	90787	86153	13847	09213	23061	59
2	76957	90777	86179	13821	09223	23043	58
3	76974	90768	86206	13794	09232	23026	57
4	76991	90759	86232	13768	09241	23009	56
5	77009	90750	86259	13741	09250	22991	55
6	77026	90741	86285	13715	09259	22974	54
7	77043	90731	86312	13688	09269	22957	53
8	77061	90722	86338	13662	09278	22939	52
9	77078	90713	86365	13635	09287	22922	51
10	9.77095	9.90704	9.86392	10.13608	10.09296	10.22905	50
11	77112	90694	86418	13582	09306	22888	49
12	77130	90685	86445	13555	09315	22870	48
13	77147	90676	86471	13529	09324	22853	47
14	77164	90667	86498	13502	09333	22836	46
15	77181	90657	86524	13476	09343	22819	45
16	77199	90648	86551	13449	09352	22801	44
17	77216	90639	86577	13423	09361	22784	43
18	77233	90630	86603	13397	09370	22767	42
19	77250	90620	86630	13370	09380	22750	41
20	9.77268	9.90611	9.86656	10.13344	10.09389	10.22732	40
21	77285	90602	86683	13317	09398	22715	39
22	77302	90592	86709	13291	09408	22698	38
23	77319	90583	86736	13264	09417	22681	37
24	77336	90574	86762	13238	09426	22664	36
25	77353	90565	86789	13211	09435	22647	35
26	77370	90555	86815	13185	09445	22630	34
27	77387	90546	86842	13158	09454	22613	33
28	77405	90537	86868	13132	09463	22595	32
29	77422	90527	86894	13106	09473	22578	31
30	9.77439	9.90518	9.86921	10.13079	10.09482	10.22561	30
31	77456	90509	86947	13053	09491	22544	29
32	77473	90499	86974	13026	09501	22527	28
33	77490	90490	87000	13000	09510	22510	27
34	77507	90480	87027	12973	09520	22493	26
35	77524	90471	87053	12947	09529	22476	25
36	77541	90462	87079	12921	09538	22459	24
37	77558	90452	87106	12894	09548	22442	23
38	77575	90443	87132	12868	09557	22425	22
39	77592	90434	87158	12842	09566	22408	21
40	9.77609	9.90424	9.87185	10.12815	10.09576	10.22391	20
41	77626	90415	87211	12789	09585	22374	19
42	77643	90405	87238	12762	09595	22357	18
43	77660	90396	87264	12736	09604	22340	17
44	77677	90386	87290	12710	09614	22323	16
45	77694	90377	87317	12683	09623	22306	15
46	77711	90368	87343	12657	09632	22289	14
47	77728	90358	87369	12631	09642	22272	13
48	77744	90349	87396	12604	09651	22256	12
49	77761	90339	87422	12578	09661	22239	11
50	9.77778	9.90330	9.87448	10.12552	10.09670	10.22222	10
51	77795	90320	87475	12525	09680	22205	9
52	77812	90311	87501	12499	09689	22188	8
53	77829	90301	87527	12473	09699	22171	7
54	77846	90292	87554	12446	09708	22154	6
55	77862	90282	87580	12420	09718	22138	5
56	77879	90273	87606	12394	09727	22121	4
57	77896	90263	87633	12367	09737	22104	3
58	77913	90254	87659	12341	09746	22087	2
59	77930	90244	87685	12315	09756	22070	1
60	77946	90235	87711	12289	09765	22054	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

53 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.77946	9.90235	9.87711	10.12289	10.09765	10.22054	60
1	77963	90225	87738	12262	09775	22037	59
2	77980	90216	87764	12236	09784	22020	58
3	77997	90206	87790	12210	09794	22003	57
4	78013	90197	87817	12183	09803	21987	56
5	78030	90187	87843	12157	09813	21970	55
6	78047	90178	87869	12131	09822	21953	54
7	78063	90168	87895	12105	09832	21937	53
8	78080	90159	87922	12078	09841	21920	52
9	78097	90149	87948	12052	09851	21903	51
10	9.78113	9.90139	9.87974	10.12026	10.09861	10.21887	50
11	78130	90130	88000	12000	09870	21870	49
12	78147	90120	88027	11973	09880	21853	48
13	78163	90111	88053	11947	09889	21837	47
14	78180	90101	88079	11921	09899	21820	46
15	78197	90091	88105	11895	09909	21803	45
16	78213	90082	88131	11869	09918	21787	44
17	78230	90072	88158	11842	09928	21770	43
18	78246	90063	88184	11816	09937	21754	42
19	78263	90053	88210	11790	09947	21737	41
20	9.78280	9.90043	9.88236	10.11764	10.09957	10.21720	40
21	78296	90034	88262	11738	09966	21704	39
22	78313	90024	88289	11711	09976	21687	38
23	78329	90014	88315	11685	09986	21671	37
24	78346	90005	88341	11659	09995	21654	36
25	78362	89995	88367	11633	10005	21638	35
26	78379	89985	88393	11607	10015	21621	34
27	78395	89976	88420	11580	10024	21605	33
28	78412	89966	88446	11554	10034	21588	32
29	78428	89956	88472	11528	10044	21572	31
30	9.78445	9.89947	9.88498	10.11502	10.10053	10.21555	30
31	78461	89937	88524	11476	10063	21539	29
32	78478	89927	88550	11450	10073	21522	28
33	78494	89918	88577	11423	10082	21506	27
34	78510	89908	88603	11397	10092	21490	26
35	78527	89898	88629	11371	10102	21473	25
36	78543	89888	88655	11345	10112	21457	24
37	78560	89879	88681	11319	10121	21440	23
38	78576	89869	88707	11293	10131	21424	22
39	78592	89859	88733	11267	10141	21408	21
40	9.78609	9.89849	9.88759	10.11241	10.10151	10.21391	20
41	78625	89840	88786	11214	10160	21375	19
42	78642	89830	88812	11188	10170	21358	18
43	78658	89820	88838	11162	10180	21342	17
44	78674	89810	88864	11136	10190	21326	16
45	78691	89801	88890	11110	10199	21309	15
46	78707	89791	88916	11084	10209	21293	14
47	78723	89781	88942	11058	10219	21277	13
48	78739	89771	88968	11032	10229	21261	12
49	78756	89761	88994	11006	10239	21244	11
50	9.78772	9.89752	9.89020	10.10980	10.10248	10.21228	10
51	78788	89742	89046	10954	10258	21212	9
52	78805	89732	89073	10927	10268	21195	8
53	78821	89722	89099	10901	10278	21179	7
54	78837	89712	89125	10875	10288	21163	6
55	78853	89702	89151	10849	10298	21147	5
56	78869	89693	89177	10823	10307	21131	4
57	78886	89683	89203	10797	10317	21114	3
58	78902	89673	89229	10771	10327	21098	2
59	78918	89663	89255	10745	10337	21082	1
60	78934	89653	89281	10719	10347	21066	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

52 Degrees

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.78934	9.89653	9.89281	10.10719	10.10347	10.21066	60
1	78950	89643	89307	10693	10357	21050	59
2	78967	89633	89333	10667	10367	21033	58
3	78983	89624	89359	10641	10376	21017	57
4	78999	89614	89385	10615	10386	21001	56
5	79015	89604	89411	10589	10396	20985	55
6	79031	89594	89437	10563	10406	20969	54
7	79047	89584	89463	10537	10416	20953	53
8	79063	89574	89489	10511	10426	20937	52
9	79079	89564	89515	10485	10436	20921	51
10	9.79095	9.89554	9.89541	10.10459	10.10446	10.20905	50
11	79111	89544	89567	10433	10456	20889	49
12	79128	89534	89593	10407	10466	20872	48
13	79144	89524	89619	10381	10476	20856	47
14	79160	89514	89645	10355	10486	20840	46
15	79176	89504	89671	10329	10496	20824	45
16	79192	89495	89697	10303	10505	20808	44
17	79208	89485	89723	10277	10515	20792	43
18	79224	89475	89749	10251	10525	20776	42
19	79240	89465	89775	10225	10535	20760	41
20	9.79256	9.89455	9.89801	10.10199	10.10545	10.20744	40
21	79272	89445	89827	10173	10555	20728	39
22	79288	89435	89853	10147	10565	20712	38
23	79304	89425	89879	10121	10575	20696	37
24	79319	89415	89905	10095	10585	20681	36
25	79335	89405	89931	10069	10595	20665	35
26	79351	89395	89957	10043	10605	20649	34
27	79367	89385	89983	10017	10615	20633	33
28	79383	89375	90009	09991	10625	20617	32
29	79399	89364	90035	09965	10636	20601	31
30	9.79415	9.89354	9.90061	10.09939	10.10646	10.20585	30
31	79431	89344	90086	09914	10656	20569	29
32	79447	89334	90112	09888	10666	20553	28
33	79463	89324	90138	09862	10676	20537	27
34	79478	89314	90164	09836	10686	20522	26
35	79494	89304	90190	09810	10696	20506	25
36	79510	89294	90216	09784	10706	20490	24
37	79526	89284	90242	09758	10716	20474	23
38	79542	89274	90268	09732	10726	20458	22
39	79558	89264	90294	09706	10736	20442	21
40	9.79573	9.89254	9.90320	10.09680	10.10746	10.20427	20
41	79589	89244	90346	09654	10756	20411	19
42	79605	89233	90371	09629	10767	20395	18
43	79621	89223	90397	09603	10777	20379	17
44	79636	89213	90423	09577	10787	20364	16
45	79652	89203	90449	09551	10797	20348	15
46	79668	89193	90475	09525	10807	20332	14
47	79684	89183	90501	09499	10817	20316	13
48	79699	89173	90527	09473	10827	20301	12
49	79715	89162	90553	09447	10838	20285	11
50	9.79731	9.89152	9.90578	10.09422	10.10848	10.20269	10
51	79746	89142	90604	09396	10858	20254	9
52	79762	89132	90630	09370	10868	20238	8
53	79778	89122	90656	09344	10878	20222	7
54	79793	89112	90682	09318	10888	20207	6
55	79809	89101	90708	09292	10899	20191	5
56	79825	89091	90734	09266	10909	20175	4
57	79840	89081	90759	09241	10919	20160	3
58	79856	89071	90785	09215	10929	20144	2
59	79872	89060	90811	09189	10940	20128	1
60	79887	89050	90837	09163	10950	20113	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

51 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.79887	9.89050	9.90837	10.09163	10.10950	10.20113	60
1	79903	89040	90863	09137	10960	20097	59
2	79918	89030	90889	09111	10970	20082	58
3	79934	89020	90914	09086	10980	20066	57
4	79950	89009	90940	09060	10991	20050	56
5	79965	88999	90966	09034	11001	20035	55
6	79981	88989	90992	09008	11011	20019	54
7	79996	88978	91018	08982	11022	20004	53
8	80012	88968	91043	08957	11032	19988	52
9	80027	88958	91069	08931	11042	19973	51
10	9.80043	9.88948	9.91095	10.08905	10.11052	10.19957	50
11	80058	88937	91121	08879	11063	19942	49
12	80074	88927	91147	08853	11073	19926	48
13	80089	88917	91172	08828	11083	19911	47
14	80105	88906	91198	08802	11094	19895	46
15	80120	88896	91224	08776	11104	19880	45
16	80136	88886	91250	08750	11114	19864	44
17	80151	88875	91276	08724	11125	19849	43
18	80166	88865	91301	08699	11135	19834	42
19	80182	88855	91327	08673	11145	19818	41
20	9.80197	9.88844	9.91353	10.08647	10.11156	10.19803	40
21	80213	88834	91379	08621	11166	19787	39
22	80228	88824	91404	08596	11176	19772	38
23	80244	88813	91430	08570	11187	19756	37
24	80259	88803	91456	08544	11197	19741	36
25	80274	88793	91482	08518	11207	19726	35
26	80290	88782	91507	08493	11218	19710	34
27	80305	88772	91533	08467	11228	19695	33
28	80320	88761	91559	08441	11239	19680	32
29	80336	88751	91585	08415	11249	19664	31
30	9.80351	9.88741	9.91610	10.08390	10.11259	10.19649	30
31	80366	88730	91636	08364	11270	19634	29
32	80382	88720	91662	08338	11280	19618	28
33	80397	88709	91688	08312	11291	19603	27
34	80412	88699	91713	08287	11301	19588	26
35	80428	88688	91739	08261	11312	19572	25
36	80443	88678	91765	08235	11322	19557	24
37	80458	88668	91791	08209	11332	19542	23
38	80473	88657	91816	08184	11343	19527	22
39	80489	88647	91842	08158	11353	19511	21
40	9.80504	9.88636	9.91868	10.08132	10.11364	10.19496	20
41	80519	88626	91893	08107	11374	19481	19
42	80534	88615	91919	08081	11385	19466	18
43	80550	88605	91945	08055	11395	19450	17
44	80565	88594	91971	08029	11406	19435	16
45	80580	88584	91996	08004	11416	19420	15
46	80595	88573	92022	07978	11427	19405	14
47	80610	88563	92048	07952	11437	19390	13
48	80625	88552	92073	07927	11448	19375	12
49	80641	88542	92099	07901	11458	19359	11
50	9.80656	9.88531	9.92125	10.07875	10.11469	10.19344	10
51	80671	88521	92150	07850	11479	19329	9
52	80686	88510	92176	07824	11490	19314	8
53	80701	88499	92202	07798	11501	19299	7
54	80716	88489	92227	07773	11511	19284	6
55	80731	88478	92253	07747	11522	19269	5
56	80746	88468	92279	07721	11532	19254	4
57	80762	88457	92304	07696	11543	19238	3
58	80777	88447	92330	07670	11553	19223	2
59	80792	88436	92356	07644	11564	19208	1
60	80807	88425	92381	07619	11575	19193	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

50 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.80807	9.88425	9.92381	10.07619	10.11575	10.19193	60
1	80822	88415	92407	07593	11585	19178	59
2	80837	88404	92433	07567	11596	19163	58
3	80852	88394	92458	07542	11606	19148	57
4	80867	88383	92484	07516	11617	19133	56
5	80882	88372	92510	07490	11628	19118	55
6	80897	88362	92535	07465	11638	19103	54
7	80912	88351	92561	07439	11649	19088	53
8	80927	88340	92587	07413	11660	19073	52
9	80942	88330	92612	07388	11670	19058	51
10	9.80957	9.88319	9.92638	10.07362	10.11681	10.19043	50
11	80972	88308	92663	07337	11692	19028	49
12	80987	88298	92689	07311	11702	19013	48
13	81002	88287	92715	07285	11713	18998	47
14	81017	88276	92740	07260	11724	18983	46
15	81032	88266	92766	07234	11734	18968	45
16	81047	88255	92792	07208	11745	18953	44
17	81061	88244	92817	07183	11756	18939	43
18	81076	88234	92843	07157	11766	18924	42
19	81091	88223	92868	07132	11777	18909	41
20	9.81106	9.88212	9.92894	10.07106	10.11788	10.18894	40
21	81121	88201	92920	07080	11799	18879	39
22	81136	88191	92945	07055	11809	18864	38
23	81151	88180	92971	07029	11820	18849	37
24	81166	88169	92996	07004	11831	18834	36
25	81180	88158	93022	06978	11842	18820	35
26	81195	88148	93048	06952	11852	18805	34
27	81210	88137	93073	06927	11863	18790	33
28	81225	88126	93099	06901	11874	18775	32
29	81240	88115	93124	06876	11885	18760	31
30	9.81254	9.88105	9.93150	10.06850	10.11895	10.18746	30
31	81269	88094	93175	06825	11906	18731	29
32	81284	88083	93201	06799	11917	18716	28
33	81299	88072	93227	06773	11928	18701	27
34	81314	88061	93252	06748	11939	18686	26
35	81328	88051	93278	06722	11949	18672	25
36	81343	88040	93303	06697	11960	18657	24
37	81358	88029	93329	06671	11971	18642	23
38	81372	88018	93354	06646	11982	18628	22
39	81387	88007	93380	06620	11993	18613	21
40	9.81402	9.87996	9.93406	10.06594	10.12004	10.18598	20
41	81417	87985	93431	06569	12015	18583	19
42	81431	87975	93457	06543	12025	18569	18
43	81446	87964	93482	06518	12036	18554	17
44	81461	87953	93508	06492	12047	18539	16
45	81475	87942	93533	06467	12058	18525	15
46	81490	87931	93559	06441	12069	18510	14
47	81505	87920	93584	06416	12080	18495	13
48	81519	87909	93610	06390	12091	18481	12
49	81534	87898	93636	06364	12102	18466	11
50	9.81549	9.87887	9.93661	10.06339	10.12113	10.18451	10
51	81563	87877	93687	06313	12123	18437	9
52	81578	87866	93712	06288	12134	18422	8
53	81592	87855	93738	06262	12145	18408	7
54	81607	87844	93763	06237	12156	18393	6
55	81622	87833	93789	06211	12167	18378	5
56	81636	87822	93814	06186	12178	18364	4
57	81651	87811	93840	06160	12189	18349	3
58	81665	87800	93865	06135	12200	18335	2
59	81680	87789	93891	06109	12211	18320	1
60	81694	87778	93916	06084	12222	18306	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

49 Degrees.

Artificial Sines, Tang. and Sec. 41 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.81694	9.87778	9.93916	10.06084	10.12222	10.18306	60
1	81709	87767	93942	06058	12233	18291	59
2	81723	87756	93967	06033	12244	18277	58
3	81738	87745	93993	06007	12255	18262	57
4	81752	87734	94018	05982	12266	18248	56
5	81767	87723	94044	05956	12277	18233	55
6	81781	87712	94069	05931	12288	18219	54
7	81796	87701	94095	05905	12299	18204	53
8	81810	87690	94120	05880	12310	18190	52
9	81825	87679	94146	05854	12321	18175	51
10	9.81839	9.87668	9.94171	10.05829	10.12332	10.18161	50
11	81854	87657	94197	05803	12343	18146	49
12	81868	87646	94222	05778	12354	18132	48
13	81882	87635	94248	05752	12365	18118	47
14	81897	87624	94273	05727	12376	18103	46
15	81911	87613	94299	05701	12387	18089	45
16	81926	87601	94324	05676	12399	18074	44
17	81940	87590	94350	05650	12410	18060	43
18	81955	87579	94375	05625	12421	18045	42
19	81969	87568	94401	05599	12432	18031	41
20	9.81983	9.87557	9.94426	10.05574	10.12443	10.18017	40
21	81998	87546	94452	05548	12454	18002	39
22	82012	87535	94477	05523	12465	17988	38
23	82026	87524	94503	05497	12476	17974	37
24	82041	87513	94528	05472	12487	17959	36
25	82055	87501	94554	05446	12499	17945	35
26	82069	87490	94579	05421	12510	17931	34
27	82084	87479	94604	05396	12521	17916	33
28	82098	87468	94630	05370	12532	17902	32
29	82112	87457	94655	05345	12543	17888	31
30	9.82126	9.87446	9.94681	10.05319	10.12554	10.17874	30
31	82141	87434	94706	05294	12566	17859	29
32	82155	87423	94732	05268	12577	17845	28
33	82169	87412	94757	05243	12588	17831	27
34	82184	87401	94783	05217	12599	17816	26
35	82198	87390	94808	05192	12610	17802	25
36	82212	87378	94834	05166	12622	17788	24
37	82226	87367	94859	05141	12633	17774	23
38	82240	87356	94884	05116	12644	17760	22
39	82255	87345	94910	05090	12655	17745	21
40	9.82269	9.87334	9.94935	10.05065	10.12666	10.17731	20
41	82283	87322	94961	05039	12678	17717	19
42	82297	87311	94986	05014	12689	17703	18
43	82311	87300	95012	04988	12700	17689	17
44	82326	87288	95037	04963	12712	17674	16
45	82340	87277	95062	04938	12723	17660	15
46	82354	87266	95088	04912	12734	17646	14
47	82368	87255	95113	04887	12745	17632	13
48	82382	87243	95139	04861	12757	17618	12
49	82396	87232	95164	04836	12768	17604	11
50	9.82410	9.87221	9.95190	10.04810	10.12779	10.17590	10
51	82424	87209	95215	04785	12791	17576	9
52	82439	87198	95240	04760	12802	17561	8
53	82453	87187	95266	04734	12813	17547	7
54	82467	87175	95291	04709	12825	17533	6
55	82481	87164	95317	04683	12836	17519	5
56	82495	87153	95342	04658	12847	17505	4
57	82509	87141	95368	04632	12859	17491	3
58	82523	87130	95393	04607	12870	17477	2
59	82537	87119	95418	04582	12881	17463	1
60	82551	87107	95444	04556	12893	17449	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

48 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.84177	9.85693	9.98484	10.01516	10.14307	10.15823	60
1	84190	85681	98509	01491	14319	15810	59
2	84203	85669	98534	01466	14331	15797	58
3	84216	85657	98560	01440	14343	15784	57
4	84229	85645	98585	01415	14355	15771	56
5	84242	85632	98610	01390	14368	15758	55
6	84255	85620	98635	01365	14380	15745	54
7	84269	85608	98661	01339	14392	15731	53
8	84282	85596	98686	01314	14404	15718	52
9	84295	85583	98711	01289	14417	15705	51
10	9.84308	9.85571	9.98737	10.01263	10.14429	10.15692	50
11	84321	85559	98762	01238	14441	15679	49
12	84334	85547	98787	01213	14453	15666	48
13	84347	85534	98812	01188	14466	15653	47
14	84360	85522	98838	01162	14478	15640	46
15	84373	85510	98863	01137	14490	15627	45
16	84385	85497	98888	01112	14503	15615	44
17	84398	85485	98913	01087	14515	15602	43
18	84411	85473	98939	01061	14527	15589	42
19	84424	85460	98964	01036	14540	15576	41
20	9.84437	9.85448	9.98989	10.01011	10.14552	10.15563	40
21	84450	85436	99015	00985	14564	15550	39
22	84463	85423	99040	00960	14577	15537	38
23	84476	85411	99065	00935	14589	15524	37
24	84489	85399	99090	00910	14601	15511	36
25	84502	85386	99116	00884	14614	15498	35
26	84515	85374	99141	00859	14626	15485	34
27	84528	85361	99166	00834	14639	15472	33
28	84540	85349	99191	00809	14651	15460	32
29	84553	85337	99217	00783	14663	15447	31
30	9.84566	9.85324	9.99242	10.00758	10.14676	10.15434	30
31	84579	85312	99267	00733	14688	15421	29
32	84592	85299	99293	00707	14701	15408	28
33	84605	85287	99318	00682	14713	15395	27
34	84618	85274	99343	00657	14726	15382	26
35	84630	85262	99368	00632	14738	15370	25
36	84643	85250	99394	00606	14750	15357	24
37	84656	85237	99419	00581	14763	15344	23
38	84669	85225	99444	00556	14775	15331	22
39	84682	85212	99469	00531	14788	15318	21
40	9.84694	9.85200	9.99495	10.00505	10.14800	10.15306	20
41	84707	85187	99520	00480	14813	15293	19
42	84720	85175	99545	00455	14825	15280	18
43	84733	85162	99570	00430	14838	15267	17
44	84745	85150	99596	00404	14850	15255	16
45	84758	85137	99621	00379	14863	15242	15
46	84771	85125	99646	00354	14875	15229	14
47	84784	85112	99672	00328	14888	15216	13
48	84796	85100	99697	00303	14900	15204	12
49	84809	85087	99722	00278	14913	15191	11
50	9.84822	9.85074	9.99747	10.00253	10.14926	10.15178	10
51	84835	85062	99773	00227	14938	15165	9
52	84847	85049	99798	00202	14951	15153	8
53	84860	85037	99823	00177	14963	15140	7
54	84873	85024	99848	00152	14976	15127	6
55	84885	85012	99874	00126	14988	15115	5
56	84898	84999	99899	00101	15001	15102	4
57	84911	84986	99924	00076	15014	15089	3
58	84923	84974	99949	00051	15026	15077	2
59	84936	84961	99975	00025	15039	15064	1
60	84949	84949	10.00000	10.00000	15051	15051	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M

45 Degrees

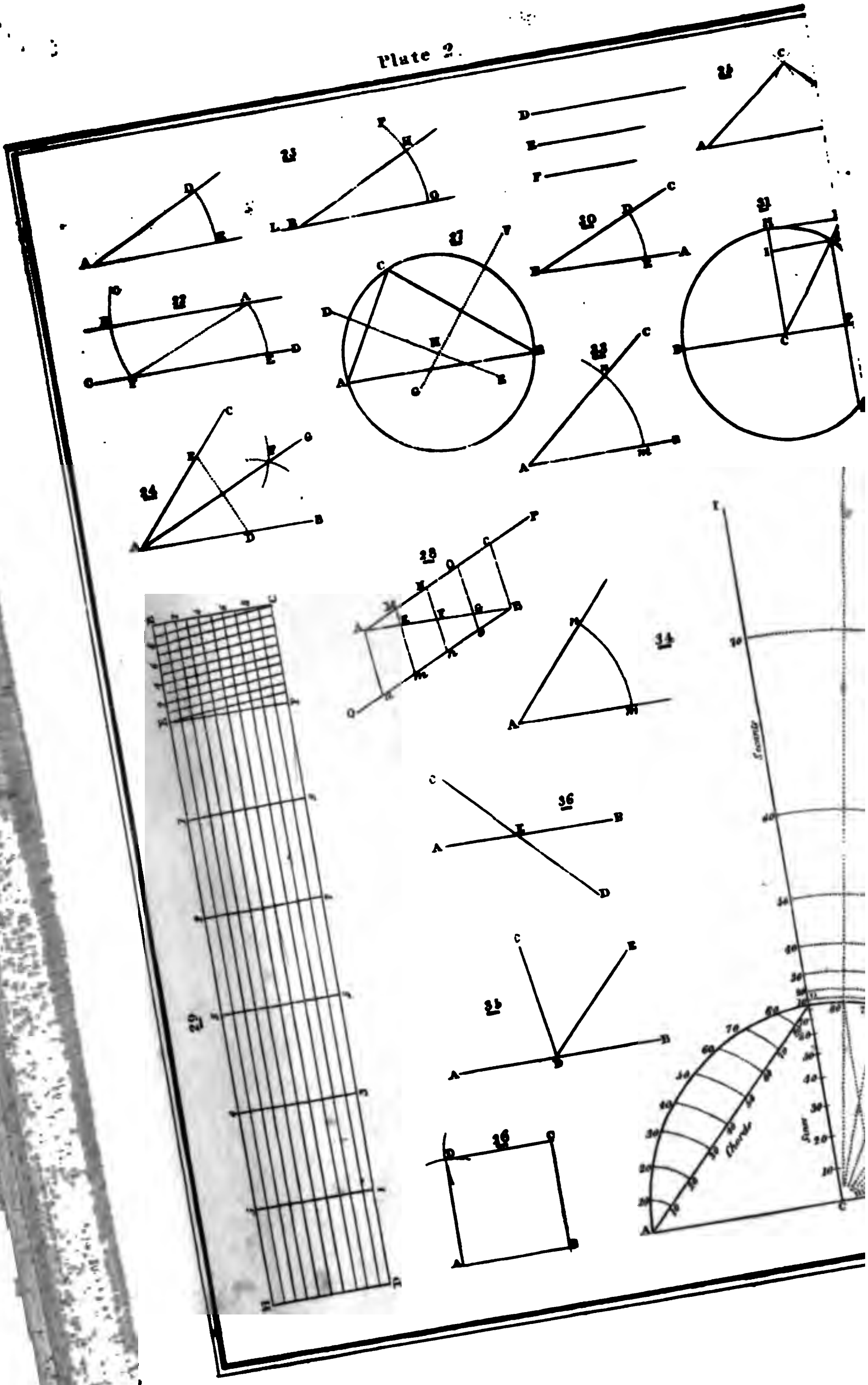
M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.83378	9.86413	9.96966	10.03034	10.13587	10.16622	60
1	83392	86401	96991	03009	13599	16608	59
2	83405	86389	97016	02984	13611	16595	58
3	83419	86377	97042	02958	13623	16581	57
4	83432	86366	97067	02933	13634	16568	56
5	83446	86354	97092	02908	13646	16554	55
6	83459	86342	97118	02882	13658	16541	54
7	83473	86330	97143	02857	13670	16527	53
8	83486	86318	97168	02832	13682	16514	52
9	83500	86306	97193	02807	13694	16500	51
10	9.83513	9.86295	9.97219	10.02781	10.13705	10.16487	50
11	83527	86283	97244	02756	13717	16473	49
12	83540	86271	97269	02731	13729	16460	48
13	83554	86259	97295	02705	13741	16446	47
14	83567	86247	97320	02680	13753	16433	46
15	83581	86235	97345	02655	13765	16419	45
16	83594	86223	97371	02629	13777	16406	44
17	83608	86211	97396	02604	13789	16392	43
18	83621	86200	97421	02579	13800	16379	42
19	83634	86188	97447	02553	13812	16366	41
20	9.83648	9.86176	9.97472	10.02528	10.13824	10.16352	40
21	83661	86164	97497	02503	13836	16339	39
22	83674	86152	97523	02477	13848	16326	38
23	83688	86140	97548	02452	13860	16312	37
24	83701	86128	97573	02427	13872	16299	36
25	83715	86116	97598	02402	13884	16285	35
26	83728	86104	97624	02376	13896	16272	34
27	83741	86092	97649	02351	13908	16259	33
28	83755	86080	97674	02326	13920	16245	32
29	83768	86068	97700	02300	13932	16232	31
30	9.83781	9.86056	9.97725	10.02275	10.13944	10.16219	30
31	83795	86044	97750	02250	13956	16205	29
32	83808	86032	97776	02224	13968	16192	28
33	83821	86020	97801	02199	13980	16179	27
34	83834	86008	97826	02174	13992	16166	26
35	83848	85996	97851	02149	14004	16152	25
36	83861	85984	97877	02123	14016	16139	24
37	83874	85972	97902	02098	14028	16126	23
38	83887	85960	97927	02073	14040	16113	22
39	83901	85948	97953	02047	14052	16099	21
40	9.83914	9.85936	9.97978	10.02022	10.14064	10.16086	20
41	83927	85924	98003	01997	14076	16073	19
42	83940	85912	98029	01971	14088	16060	18
43	83954	85900	98054	01946	14100	16046	17
44	83967	85888	98079	01921	14112	16033	16
45	83980	85876	98104	01896	14124	16020	15
46	83993	85864	98130	01870	14136	16007	14
47	84006	85851	98155	01845	14149	15994	13
48	84020	85839	98180	01820	14161	15980	12
49	84033	85827	98206	01794	14173	15967	11
50	9.84046	9.85815	9.98231	10.01769	10.14185	10.15954	10
51	84059	85803	98256	01744	14197	15941	9
52	84072	85791	98281	01719	14209	15928	8
53	84085	85779	98307	01693	14221	15915	7
54	84098	85766	98332	01668	14234	15902	6
55	84112	85754	98357	01643	14246	15888	5
56	84125	85742	98383	01617	14258	15875	4
57	84138	85730	98408	01592	14270	15862	3
58	84151	85718	98433	01567	14282	15849	2
59	84164	85706	98458	01542	14294	15836	1
60	84177	85693	98484	01516	14307	15823	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

46 Degrees.

M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	
0	9.84177	9.85693	9.98484	10.01516	10.14307	10.15823	60
1	84190	85681	98509	01491	14319	15810	59
2	84203	85669	98534	01466	14331	15797	58
3	84216	85657	98560	01440	14343	15784	57
4	84229	85645	98585	01415	14355	15771	56
5	84242	85632	98610	01390	14368	15758	55
6	84255	85620	98635	01365	14380	15745	54
7	84269	85608	98661	01339	14392	15731	53
8	84282	85596	98686	01314	14404	15718	52
9	84295	85583	98711	01289	14417	15705	51
10	9.84308	9.85571	9.98737	10.01263	10.14429	10.15692	50
11	84321	85559	98762	01238	14441	15679	49
12	84334	85547	98787	01213	14453	15666	48
13	84347	85534	98812	01188	14466	15653	47
14	84360	85522	98838	01162	14478	15640	46
15	84373	85510	98863	01137	14490	15627	45
16	84385	85497	98888	01112	14503	15615	44
17	84398	85485	98913	01087	14515	15602	43
18	84411	85473	98939	01061	14527	15589	42
19	84424	85460	98964	01036	14540	15576	41
20	9.84437	9.85448	9.98989	10.01011	10.14552	10.15563	40
21	84450	85436	99015	00985	14564	15550	39
22	84463	85423	99040	00960	14577	15537	38
23	84476	85411	99065	00935	14589	15524	37
24	84489	85399	99090	00910	14601	15511	36
25	84502	85386	99116	00884	14614	15498	35
26	84515	85374	99141	00859	14626	15485	34
27	84528	85361	99166	00834	14639	15472	33
28	84540	85349	99191	00809	14651	15460	32
29	84553	85337	99217	00783	14663	15447	31
30	9.84566	9.85324	9.99242	10.00758	10.14676	10.15434	30
31	84579	85312	99267	00733	14688	15421	29
32	84592	85299	99293	00707	14701	15408	28
33	84605	85287	99318	00682	14713	15395	27
34	84618	85274	99343	00657	14726	15382	26
35	84630	85262	99368	00632	14738	15370	25
36	84643	85250	99394	00506	14750	15357	24
37	84656	85237	99419	00581	14763	15344	23
38	84669	85225	99444	00556	14775	15331	22
39	84682	85212	99469	00531	14788	15318	21
40	9.84694	9.85200	9.99495	10.00505	10.14800	10.15306	20
41	84707	85187	99520	00480	14813	15293	19
42	84720	85175	99545	00455	14825	15280	18
43	84733	85162	99570	00430	14838	15267	17
44	84745	85150	99596	00404	14850	15255	16
45	84758	85137	99621	00379	14863	15242	15
46	84771	85125	99646	00354	14875	15229	14
47	84784	85112	99672	00328	14888	15216	13
48	84796	85100	99697	00303	14900	15204	12
49	84809	85087	99722	00278	14913	15191	11
50	9.84822	9.85074	9.99747	10.00253	10.14926	10.15178	10
51	84835	85062	99773	00227	14938	15165	9
52	84847	85049	99798	00202	14951	15153	8
53	84860	85037	99823	00177	14963	15140	7
54	84873	85024	99848	00152	14976	15127	6
55	84885	85012	99874	00126	14988	15115	5
56	84898	84999	99899	00101	15001	15102	4
57	84911	84986	99924	00076	15014	15089	3
58	84923	84974	99949	00051	15026	15077	2
59	84936	84961	99975	00025	15039	15064	1
60	84949	84949	10.00000	10.00000	15051	15051	0
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M.

45 Degrees

Plate 2.



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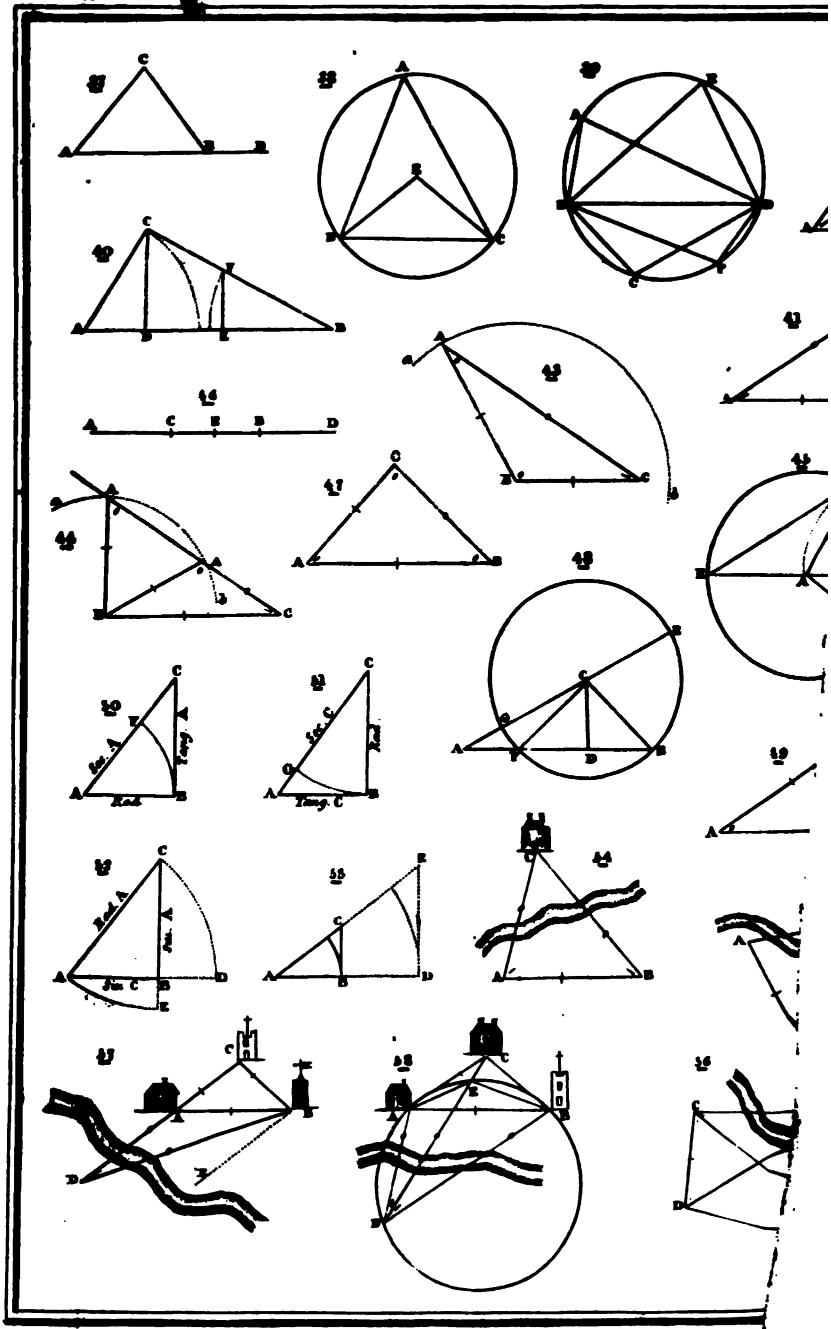
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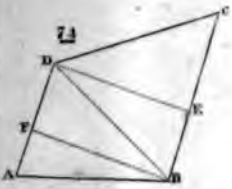
Tang. A
Rad.
Sec. C
Rad.
Tang. C
Rad. A
Sin. A
Sin. C

74



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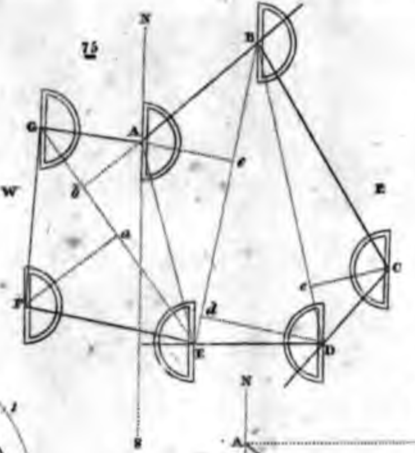

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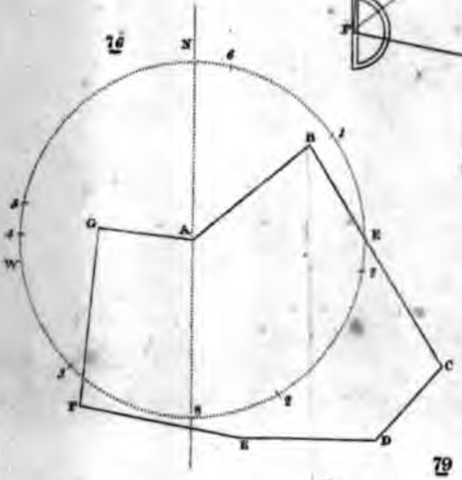

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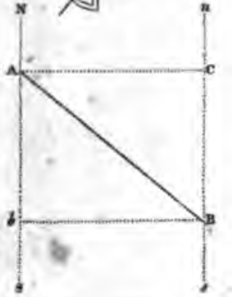

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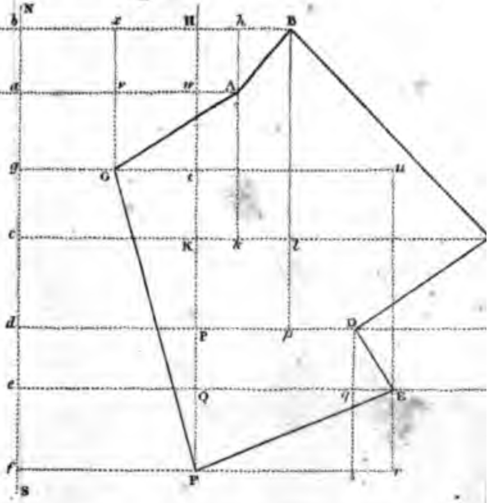

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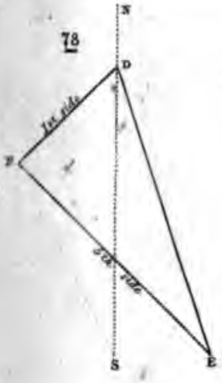

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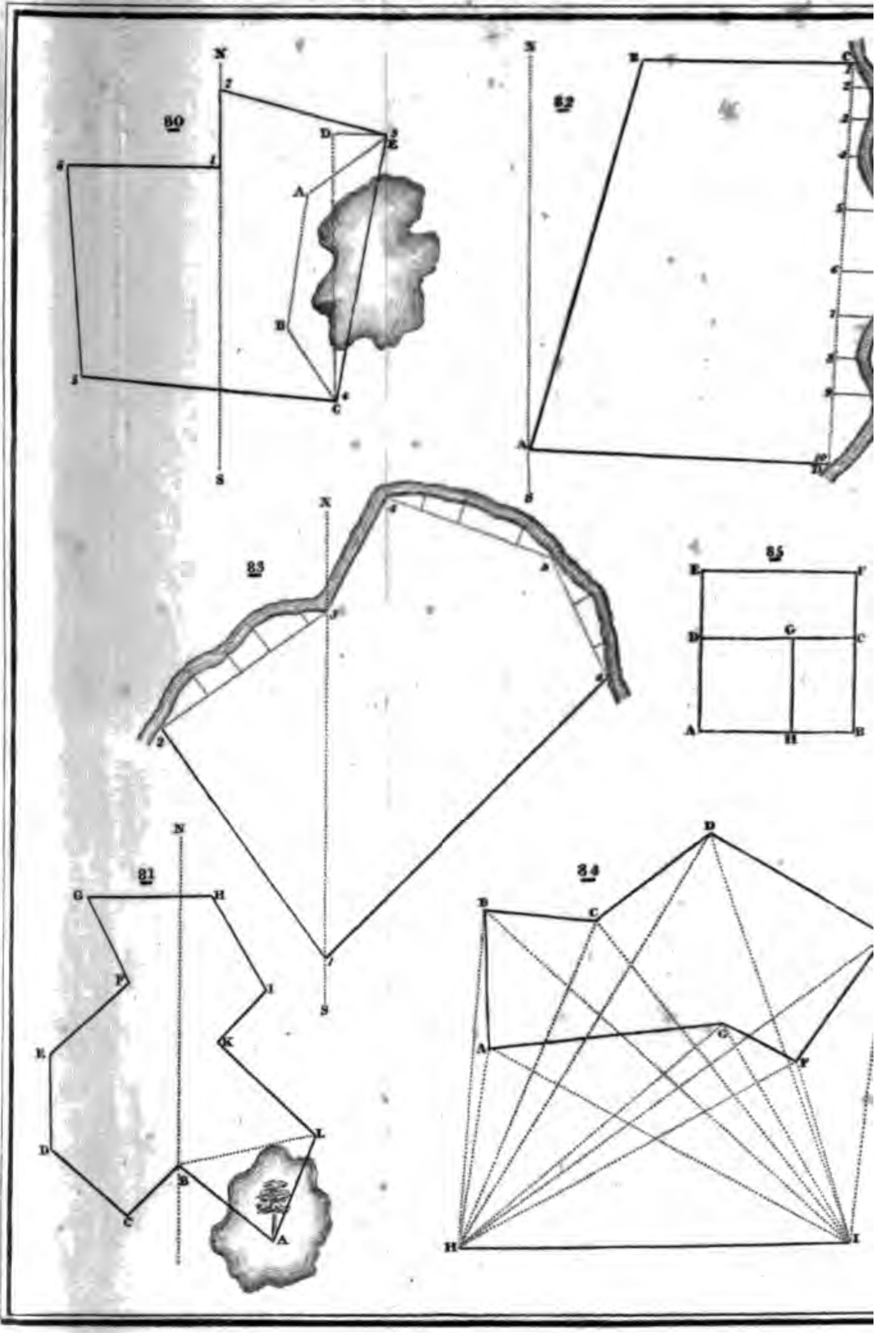
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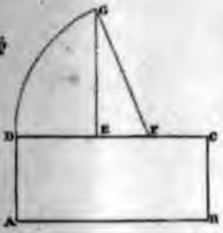
Plate. 7.

86



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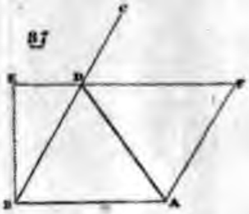

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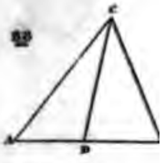

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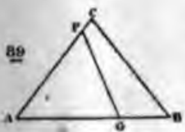

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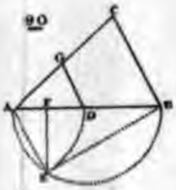

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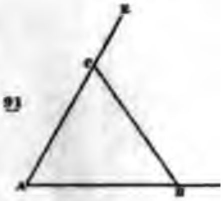

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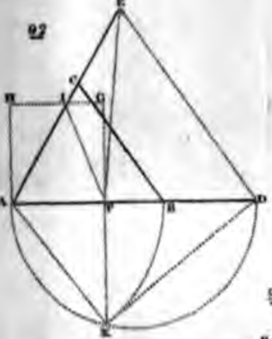

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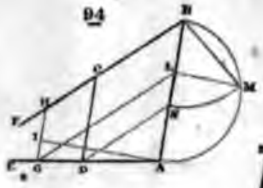

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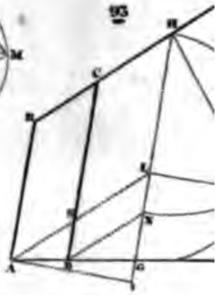

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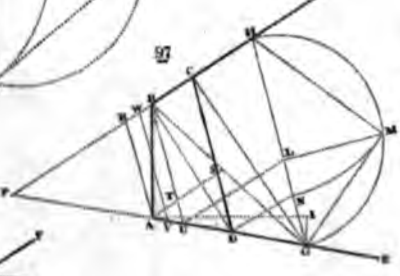

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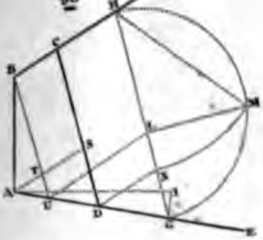

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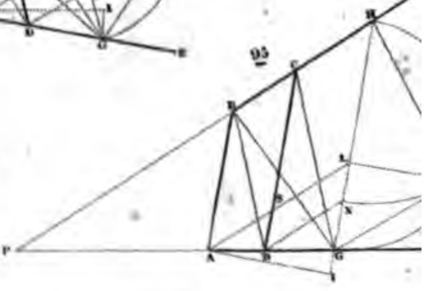

Plate II